February, 1977
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Technology Review

Edited at the Massachusetts Institute of Technology

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Energy... Canned in America.

A practical electric car could go a long way toward reducing America's dependence upon foreign oil. To satisfy a large fraction of U.S. urban driving needs, such a car should double or triple the range of present electric vehicles. Urban driving ranges of 30-50 kilometers are now offered by improved lead-acid batteries with specific energies of about 35 watt-hours per kilogram.

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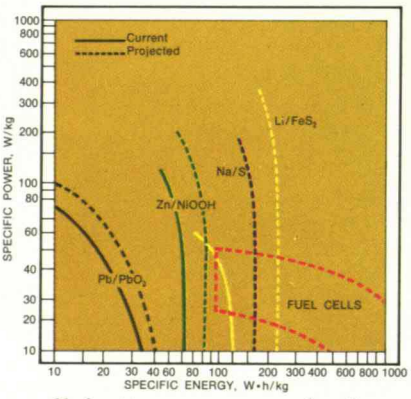

The performance of other electrical energy systems we're studying is shown in the graph. Much closer to commercial application are our ambient-temperature batteries of zinc/nickel oxide. These may almost triple the range of small, battery-powered urban cars.

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General Motors Research Laboratories
Warren, Michigan 48090

Edited at the
Massachusetts Institute of Technology

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Technology Review

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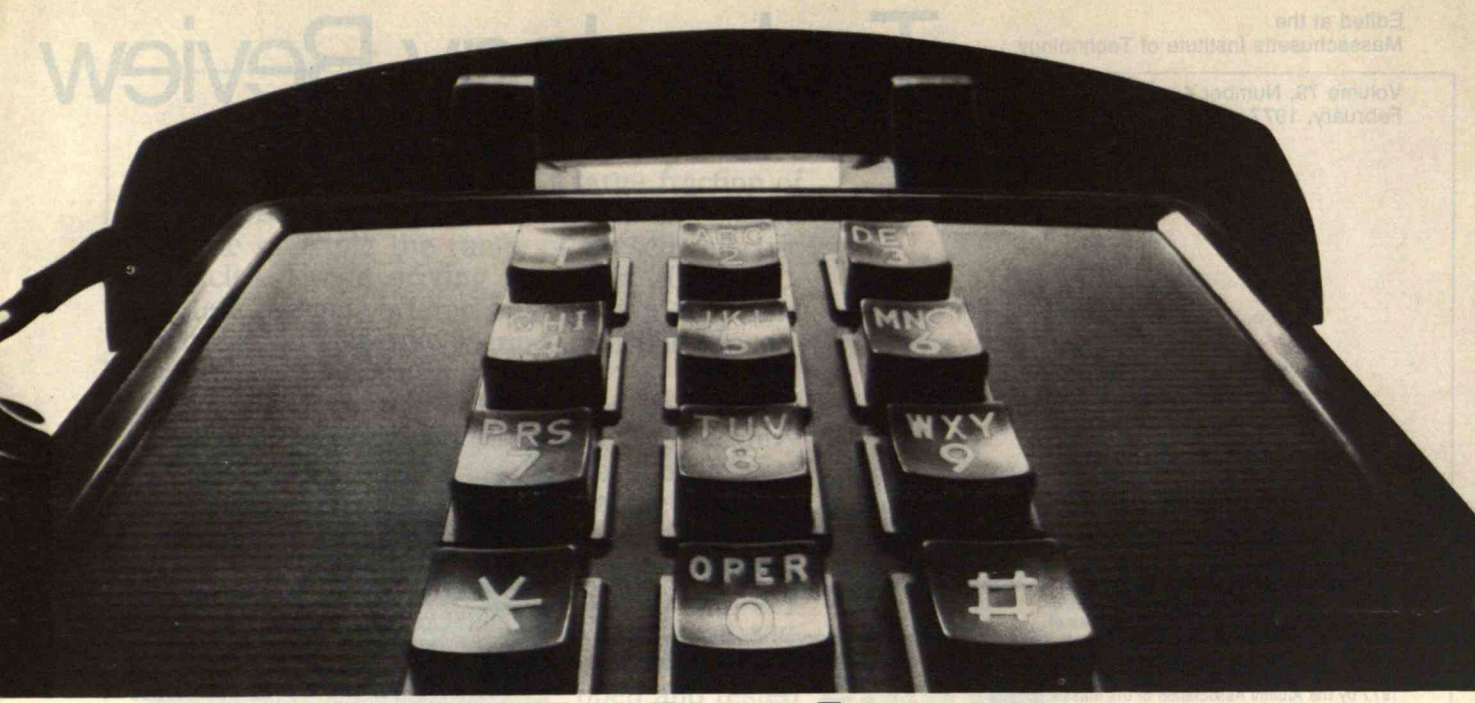

Behind the buttons, there's a "brain."

Electronic intelligence has come to the phone system.

It's part of our new electronic switching machines, working round-the-clock to give you better phone service.

And it's another innovation in telecommunications from Bell Labs and Western Electric.

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The System Works.

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Because only the Bell System has Bell Laboratories and Western Electric working together to make your telephone system the most reliable and least expensive in the world.

Which is to say, we had the brawn to put a "brain" behind your phone.

One of a series of messages to keep you informed of how telecommunications technology is changing our world—and the part Bell Labs, Western Electric and your Bell Telephone Company are playing in it.

Western Electric / Bell Laboratories

The First Line

We Rejoice: An Old Friend Returns

Robert C. Cowen began a notable series of contributions to *Technology Review* (in a department then called "Review on Science") in November, 1966; they continued without interruption until expanded duties as a senior editor of the *Christian Science Monitor* preempted his time and energy in 1973.

Now Mr. Cowen has engineered his return to full-time science writing, which is clearly his first love (excepting possibly gourmet cooking and explorations of woods and fields in Concord, Mass.). And this month he begins a new series of reports for *Technology Review*. We rejoice.

Our mail made it clear that his earlier contributions to *Technology Review* were among our most popular features. Old friends will welcome Mr. Cowen back, as we do; and new readers of the *Review* will soon enough learn to do so, as well.

Mr. Cowen studied meteorology at M.I.T. (S.B. 1949, S.M. 1950) and immediately upon graduation began his career as a science writer for the *Monitor*. He is a former President of the National Association of Science Writers, of which he has been a member since 1952; and he has been often honored for contributions to the wider understanding of science and the public issues surrounding it. — *J.M.*

Letters

The Need to Believe

Martin Gardner's article is fascinating (*"Magic and Paraphysics," June, 1976, pp. 42-51*) but an important point was not made: people believe in things for reasons other than rational ones. Whether we are talking of Geller, von Däniken, or Adamsky, we should keep in mind that the desperate personal needs of the individual are more important than the results of controlled experiments. We cannot reduce the amount of anti-reasonable popular belief in psi or astrology or UFOs until we recognize that believers need to believe.

This prompts the frightening question, which of the generally held beliefs of the scientific community are accepted for other than rational reasons?

Michael A. Seeds
Lancaster, Penn.

Velikovsky's Truth

Jerome Lettvin takes a sideswipe at Velikovsky (*"The Use of Myth," June, 1976, pp. 52-57*) and goes on to cite evidence in support of Lockyer that also supports Velikovsky.

Lockyer thought that myths are stories about natural science and history. Velikovsky thinks so, too, and includes the stories in the Old Testament. Velikovsky does not claim to be the first to reach this conclusion. Though he does not refer to Lockyer, the omission is understandable since Lockyer's work was not in currency when Velikovsky was writing. Indeed, Velikovsky believes that many discoveries hailed as original in science are in fact rediscoveries — the original having been ignored in its time.

Professor Lettvin says that anyone can speculate that this or that might be true. And when "outsiders" point out something that "establishment" historians and scientists have missed, the establishment is furious. The speculator's credentials will be attacked, and his right to investigate outside his own field will be challenged. His evidence will be ignored.

Those who wish to sort through the mess can examine the evidence for themselves. Read Velikovsky's books, then decide.

Howard Schaffer
Peiton, Taiwan

Safe Doses of Carcinogens?

When a scientist ventures beyond the perimeters of his field and attempts to influence economic and political activity, he frequently loses his scientific objectivity. This is certainly true of Dr. Samuel Epstein's foray into "The Political and Economic Basis of Cancer" (*July/August, 1976, pp. 34-43*).

Despite Dr. Epstein's exceptional academic qualifications, there appear to be a number of glaring departures from scientific fact and logic.

For one, he states that "In carcinogenicity tests, animals must be subjected to relatively high concentrations of the test substance" — but he ignores the fact that low levels of a substance may be harmless (to mice or men), and that high concentration tests may indict a substance which, under the lower levels to which men may be exposed, is harmless.

Second, Dr. Epstein appears to ignore the fact that metabolism frequently converts toxic substances to less toxic or harmless products. Dr. Anna Baetjer of the Johns Hopkins School of Hygiene and Public Health points out that 3,4 benzopyrene causes cancer in animals, and is found in the air of many cities. Nevertheless, roofers exposed to 1,000 times the concentration found in city air do not exhibit a significant increase in incidence of lung cancer. Yet Dr. Epstein insists all carcinogenic materials must be reduced to the lowest detectable level.

Third, since Dr. Epstein ignored the protective action of human metabolism, he ignores the fact that human metabolism may act quite differently than animal metabolism. Dr. Baetjer notes that neither rats nor mice develop cancer from Beta naphthylamine because the metabolic pathway in these animals is quite different from that in dogs and men.

Fourth, Dr. Epstein notes that "every chemical known to be carcinogenic to humans, with the possible exception of tri-valent arsenic, is also carcinogenic to animals." He cites this as evidence that animal tests are enough to indict a substance as being probably carcinogenic to man. But nowhere does Dr. Epstein state that every substance found to be carcinogenic to animals is carcinogenic to man. But he would have us act on that unstated and unproved assumption.

Fifth, Dr. Epstein holds that all possible carcinogens must be reduced to zero (or the lowest measurable concentration) on the theory that "safe levels of human exposure to carcinogens cannot be predicted." Dr. Baetjer, on the other hand, refers to several recent epidemiological studies that showed a definite trend of increased rates with both duration and concentration of exposure, and under some circumstances indicated a level of duration below which the cancer rate did not significantly exceed the expected rate.

Sixth, Dr. Epstein seems to take an ambivalent position with respect to cancer caused by smoking and that due to other causes. He notes that, "Much of the overall increase in cancer mortality since 1933 is attributable to lung cancer, and is due to smoking." He also identifies smoking "as the largest single cause of cancer deaths." But then he goes on to cite with approval estimates that "70 to 90 per cent of human cancers are environmentally induced or related." If the major cause of cancer is self-induced by smoking, how can 70 to 90 per cent be environmentally induced?

Seventh, Dr. Epstein makes a great leap when he states that "The majority of human cancers are environmental in origin, and therefore preventable." The unfounded assumption of an environmental basis for most cancers — even if it could be proved — tells us nothing about how to bring all of the environmental factors (including terpenes in a virgin pine forest) under control.

While the article seeks to arouse concern by discussing carcinogenic substances, the solution, typical of those who believe that big government is the answer to all problems, covers *all* toxic substances.

Leo Teplow
Gaithersburg, Md.

Mr. Teplow retired in 1970 as an officer of the American Iron and Steel Institute. — Ed.

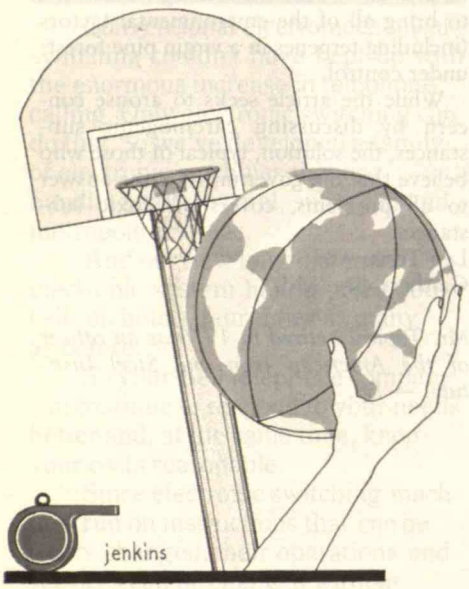
This Sporting Life

Technology/Society
by
Kenneth E. Boulding

"Democracy is to war what a tournament is to battle."

Throughout my life I have avoided sports the way some of my esteemed colleagues avoid religion. I went to one football game some 30 years ago and decided it was not only boring but beyond my intellectual capacity; I have not been to another one since. I am not averse to gentle exercise (swimming around in an empty pool, or climbing a 14,000 ft. mountain), but anything which involves dressing up in outlandish clothes and running around on a field or a court is not my thing.

One of our sons is a sports fan of first magnitude, and something of a basketball star in his college, so out of a sense of family duty I allowed my wife to take me to watch him play, in a structure that could easily pass for a modernistic cathedral. It was a rewarding experience, for I had a flash of inspiration. The game was nip and tuck, the score oscillated first to one side and then to the other, then finally the other team got the edge and the score was relentlessly increased in its favor. I almost felt a twinge. Being somewhat immune to twinges, however, the feeling soon passed and the old analytical powers reasserted themselves.



I was clearly witnessing a tribal rite, but of a very peculiar sort. It was not as these things generally are — an invocation to the gods for their support. Rather, it was a simulation of social conflict limited by rules, subjected to order. This no doubt was imposed according to some hierarchy. I perceived two gentlemen on the court, obviously elders of the tribe in mufti, who carried whistles and made strange, symbolic gestures which clearly commanded authority. They had no policemen to back them up, however, and I detected a remarkable social contract, subject like all social contracts to a bit of fudging and manipulation.

Scoring Social Points

Looking at a basketball game as a simulated society, one is struck immediately by the fact that it combines cooperation and competition, as almost all social operations do. The game represents behavior of a complex organization — the team — consisting of five independent decisionmakers. There is a relatively simple objective function, the score, which is the equivalent of accounting profit.

The parallel of profit is remarkably exact. The prime interest is in the relative score of the two teams, so that the capacity of the firm to survive depends on its rate of profit relative to other firms and other industries rather than on any absolute number. Yet a game with high scores for both teams, while it does not "count" in the relative standings, does seem to give more pleasure to the spectators. My suggestion that the scores might easily be reduced by raising the basket was met with the hoots of derision it no doubt deserved. The simulation is imperfect, however, and could be improved if the high-scoring team were allowed to have more players. If the high-scoring team were allowed to take players from the other team, of course, this might rapidly lead to a monopoly in which the losing team would be reduced to zero, and the game ended. If there were diseconomies of scale, however, so that the players on the larger team kept falling over one another, losing efficiency, we might find some equilibrium distribution of size rather like the automobile industry. The game could be improved, of course, if there were three teams playing in a triangular court with three baskets, introducing the delicious complexities of the three-body problem.

The efficiency of each team seems to depend on a very subtle and shifting division of labor. Everybody is allowed to score, but the secret to scoring seems to be passing the ball from one to another until the most favorably situated gets it in the basket. Parallels to this form of organization in the business firm would be fascinating to explore.

One sees in the competition of the two teams a parallel to collective bargaining. The importance of deceit — pretending to throw the ball one way and actually throwing it another — is particularly interesting. The constant violation of rules and the imposition of penalties is something which surely could be explored further in actual collective bargaining operations. The nimble feet of the skilled player are irresistibly reminiscent of the nimble language of the skilled bargainer.

Ritual Struggle

Most significant, however, are the political implications — both domestic and international — of basketball. A team sport is a ritual dialectic. It does not really matter who wins, but everybody has to pretend very hard that it does. If it ever really mattered who won, the game would disintegrate. One team would poison the beer of the other. Even if one team won all the time, the game would disintegrate. The game depends on a strong random element in the outcome and on a constantly shifting pattern of success from one team to another. On the other hand, if the pretense that it mattered who won were ever given up, the game would also disintegrate. There must be passionate illusion, unconscious pretense, simulated loyalty; otherwise, sports would disappear.

The parallel to political conflict in a successful and mature democracy is very striking. The last election is a particularly good example: in the two-party game the candidates have to slide towards the middle in order to be evenly matched. They must pretend very passionately that it

matters who wins. On the other hand, it mustn't matter all that much or the system would be destroyed, for the loser would refuse to accept the verdict. Democracy is to war what a tournament is to a battle. It is again a ritual dialetic, and the ritualization of dialectic is the only way to prevent its becoming intolerably costly and destructive to all parties and an insufferable burden on mankind. Those who take dialectics too seriously, like Hitler and Lenin, are the real enemies of the human race.

In the international system we are moving towards a ritual dialectic; we are still not quite there. In the wars of the 20th century, the losers have frequently done better than the victors. It is clear that both empire and territory are 90 per cent sham. One could argue that over the long history of the human race the dialectic of war has changed the names and the faces, the languages and the symbols of the human race; it has made remarkably little difference to the realities, or to the long, slow, relentless, seemingly inevitable evolution of knowledge and technology. One does not want to say that names, faces, languages, and symbols are unimportant — for those who lose dialectical struggles they are often very important — but the great hope of the human race is that they are peripheral enough so that a ritual dialectic even in the international system is possible. This is the hope of peace.

The odd thing about basketball is that it is peace: it is regulated conflict, justice imposed by impartial referees (we hope). The competition is real — somebody wins and somebody loses — but essentially a ritual, so that gain and loss are bearable. The ball passes from one team to the other according to reasonably well defined rules, designed originally to create excitement without damage.

One always worries, of course, about the stability of such a system. Even in basketball injuries escalate. The game gets rougher and more serious. The task of the referee becomes increasingly difficult. The rules are violated with increasing impunity. Perhaps, horror of horrors, it will escalate to the mutual poisoning of beer and it will become war. But this seems improbable and, if we can have stable basketball, we should have stable peace.

Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado; he writes regularly for Technology Review.

Of Human Bondage

"There is severe need for an international body . . . to keep track of alleged infringements of scientists' rights."

National Report by Colin Norman

When Galileo was forced to recant his heretical theories about the movement of the planets, he was neither the first nor the last scientist to pay a high price for espousing heterodox scientific or political views. In fact, violations of the human and professional rights of scientists — ranging from imprisonment to more subtle actions such as restricting access to scientific information — have reached alarming proportions in many parts of the world. And few countries can boast an entirely unblemished record.

Consequently, there has been much discussion recently of whether, or how, scientists should respond to alleged incidents of political repression of their colleagues. A good deal of attention has centered on the responsibilities of bodies such as the National Academy of Sciences and the Royal Society of London to protest such acts. But little has been resolved, and even less has been accomplished.

Unfortunately, one doesn't have to look far to find examples of gross violations of the human rights of scientists and others whose political philosophies conflict with those of their government. There have been numerous reports of political repression in many Latin American countries, notably Chile, Argentina, and Brazil. Many people, but particularly scientists, have been arrested, put into psychiatric institutions, or fired from their jobs in the Soviet Union for expressing opinions unpalatable to the Party rulers or because they applied for visas to emigrate. And in the not too distant past, the McCarthy investigations in the United States deprived many people of jobs for political reasons.

Examples of less blatant political repression are even more numerous and can be equally damaging to research. They include such actions as censorship of scientific journals, refusal to grant travel permits for scientists to attend meetings abroad, denial of entry visas to some scientists by a country hosting a scientific conference, and refusal to allow some scientists to publish the results of their research.

Scientific research depends critically on the ability of scientists to meet, discuss and criticize their theories, and publish their work freely. A report soon to be published by the Council for Science and Society in Britain sums the effect of even minor restrictions on the ability of scientists to communicate with one another: they "can sharply reduce the opportunities for verification and falsification, lead to unnecessary duplication of work, and hamper progress in the field of inquiry."

So it follows that infringements of the human or professional rights of scientists in one country should concern their colleagues elsewhere. To the extent that such actions inhibit the free flow of scientific information, they harm the overall potential of the scientific community. Of course, there are also humanitarian reasons why scientists should be concerned about the plight of their foreign colleagues.

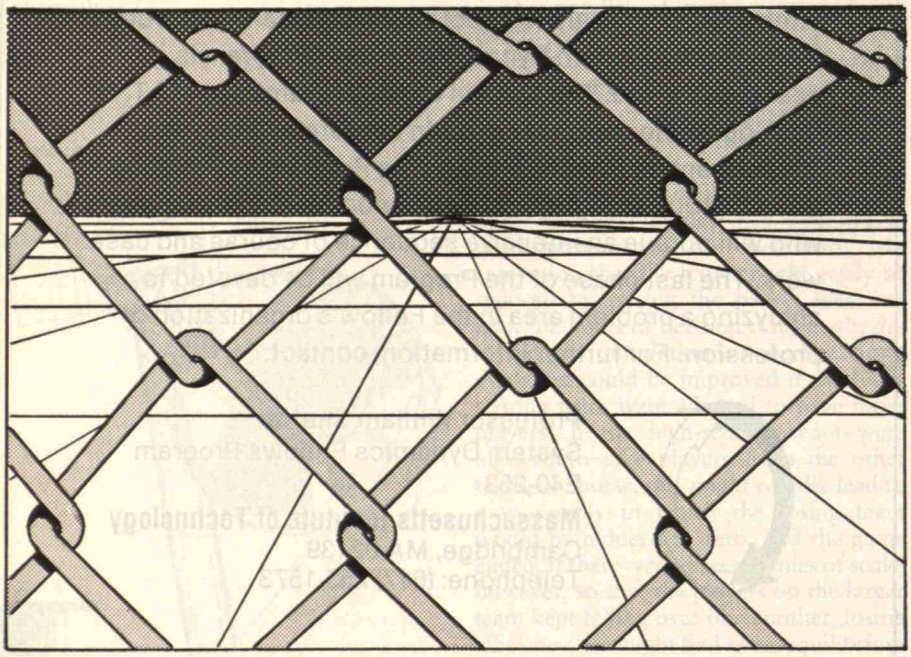


Illustration: Judy Richland

Paper Freedoms

The rights of scientists, like those of other people, fall under a number of international agreements and declarations, the most important of which is the Universal Declaration of Human Rights (U.D.H.R.), a declaration adopted unanimously by the U.N. General Assembly in 1948. Other important agreements which are supposed to protect individual rights are the so-called Helsinki Agreement, under which the signatories, including the United States and the Soviet Union, undertook to guarantee their citizens such rights as freedom to travel and to emigrate, and the European Convention on Human Rights and Fundamental Freedoms, an agreement among 18 European countries designed to implement the U.D.H.R.

Such agreements are not easy to enforce, however, and they also do not cover completely the professional rights of scientists and other scholars. Nevertheless, few countries that are parties to human rights conventions relish public exposure of their failure to observe international agreements.

Attempts to bring infringements of human rights to public attention have so far been sporadic and uncoordinated. But

some good work has nevertheless been done by the International Council of Scientific Unions (I.C.S.U.) in its attempt to remove restrictions on attendance at international conferences, and by the Federation of American Scientists (F.A.S.), the Committee of Concerned Scientists, and Amnesty International. More could be accomplished, however, by a coordinated approach.

Pressure of Publicity

In the past, public protest has proved an effective check on infringements of human rights. It is generally agreed, for example, that international expressions of concern — including a public protest by the National Academy of Sciences — have so far been instrumental in preventing the arrest of Andrei Sakharov. And other protests have been credited with securing the release of Soviet scientists Zhores Medvedev and Leonid Plyusch. Yet, learned societies such as the National Academy and the Royal Society of London have generally shied from public protest.

Early last year, however, a public argument broke out over the Academy's record. It began with criticisms from Jeremy J. Stone, Director of the F.A.S., that Academy officials had harmed the cause of dissident Soviet scientists by refusing to meet with some of them on a visit to Moscow, and it progressed to a general dispute over the Academy's responsibility to speak out in public against violations of scientists' rights. The outcome is that the Academy has set up a special committee to study its political responsibilities, and has adopted guidelines for future action when gross violations of human rights of scientists are brought to its attention. The guidelines state that the Academy will issue public protests, and even consider withdrawing from scientific exchange agreements when circumstances demand.

Unfortunately, the Royal Society — a body which commands considerable respect around the world, has declined to take so active a role. In a recent speech to Royal Society Fellows, Lord Todd, President, deplored incidents of repression against scientists, but stated that the Royal Society has no right to protest them publicly. Lord Todd did say that he would continue to make private appeals on behalf of beleaguered scientists, but those appeals are unlikely to be very effective without more substantial threat to back them up.

The report of the British Council on Science and Society provides a succinct statement of the responsibilities of learned societies. It urges them "never to falter in exhibiting in public their constant concern for the freedom of inquiry, research, and communication which is essential if the pursuit of knowledge is to continue untrammelled, and to use every possible opportunity to protest publicly against attempts to restrict that freedom." The report continues, "We are convinced that this duty is laid upon them, not only by their own charters but as the collective voice of their members, whose individual responsibilities in such matters cannot be otherwise met in full." It is worth noting that the report was produced by a committee of seven people, four of whom are members of the Royal Society, and chaired by John Ziman, himself a highly regarded Society member.

There is severe need for an international body supported by nongovernmental groups to keep track of alleged infringements of scientists' rights, and to measure the record of individual countries. Such a body could play a key role in alerting the international scientific community to repression.

Colin Norman is Washington Correspondent for Nature *and a regular contributor to the* Review.

Confessions of a Reluctant Consumer

Technology/Environment
by
Ian C.T. Nisbet

"Many social changes, including changes in patterns of consumption, can only be initiated by individuals."

"Environment" is an overused word which is commonly thought to refer to objects and values outside the usual purview of economic analysis. Many people think of clean air, pure water, open space, and wildlife as desirable things which society should reasonably spend money to preserve when there is wealth to spare, but which have to be sacrificed for the general good in bad economic times. When we complain about pollution or degradation of natural resources, we tend to blame others for selfishly exploiting them. But every action we take ourselves — eating a hamburger, for example, or driving down the street — contributes to pollution and degradation of natural resources, and others have an equal right to blame us for our selfishness.

By the phrase "our impact on the environment," we really mean the entire spectrum of indirect effects which our actions have upon the interests of others. The term should not be limited to effects upon air, water, and wildlife, nor to effects which cannot be expressed in quantitative terms: the indirect impact of our actions on the interests of others actually includes some strictly economic effects, such as insurance costs and rising prices of scarce resources. Indeed, when we analyze carefully the origins of some of our economic woes, we find that problems such as unemployment, taxes, rising prices, inflation, and crime are to a substantial extent environmental problems — in the sense that they can be traced in part to the selfish exploitation of common environmental resources.

Once we realize that the "environment" is the environment of people, and that in our daily activities we are simultaneously perpetrators and victims of environmental degradation, we can start to examine the impact of these everyday actions in a new light. In weighing the effects of our actions on the interests of others, it is good to bear in mind an environmental version of the Golden Rule: "Never do to the environment of others what you would not have them do to yours." Thus, for example, when we drive down someone else's street, we should remember the air pollution, noise, inconvenience, danger, and stress that we experience when other people drive down ours.

There is comparatively little that an individual, acting alone, can do to change those aspects of the economy that are environmentally damaging. But many social changes, including changes in patterns of consumption, can only be initiated by individuals. There is a surprisingly great opportunity for individuals to reduce their own impact, if they are willing to accept that unilateral actions will not bring them immediate reciprocal benefits. Indeed, some of the major decisions that we make about our life-styles have very important impacts on the interests of others, and we might make them differently if we thought carefully in advance about their environmental implications.

A Growing Human Family

Probably the most important single environmental decision that each person makes is how many children to have. According to one estimate, the average baby born in the U.S. today will consume in the course of a lifetime 45 tons of steel, 90,000 gallons of gasoline, 60 million gallons of water, 600 tons of stone, sand, and gravel, and generate a million gallons of sewage and 180 tons of trash. Thus it makes a great deal of difference whether a couple decides to have one, two, or three children — or none at all.

The choice of family size is usually considered an exclusively personal and private matter. Alas, in these days it is a matter of vital interest to society. Apart from the inescapable economic interdependencies of industrialized society, a large fraction of the direct costs of raising children and maintaining population growth is paid not by the parents but by society as a whole — in the form of taxes for public education insurance premiums, social security, and health insurance. The high birth rates of recent decades have led to a distorted age structure in the U.S., in which an unreasonably large fraction of the population is economically dependent upon an unreasonably small fraction of workers. Today's school-leavers and new college graduates who now find themselves unemployed have good reason to condemn as socially irresponsible their parents' contemporaries who chose to have four or five children in the 1950s. And to consider more conventional environmental matters, every increase in population that we permit or encourage will increase the next generation's problems of pollution, crowding, and resource scarcity. To take only the resource factors listed above, how can we contemplate a doubling in output of steel, water, food, sewage, and trash, if the U.S. population should double? There are ample social and environmental reasons for limiting family sizes to or below population replacement levels.

Options

After family size, selection of one's occupation is probably the second most important environmental decision one can make. Most people review their employment situation frequently, but probably few place high weight on the environmental impact of their work when they do so. We should consider environmental factors more often if we are truly to be socially responsible. Of course, it is not at all easy to assess the full environmental ramifications of one's work: there are responsible, constructive jobs even within irresponsible, damaging corporations. But too many intelligent people are content to earn a living producing or selling trivial, wasteful, or harmful products. If more of these people would vote with their feet by transferring to more responsible positions this could improve the environment more effectively than a host of regulatory restrictions.

Among the every day activities which have adverse effects upon the interests of others, automobile driving is one of the easiest to curtail. Modern society has made many of us slaves to the automobile, but if we carefully analyze the net benefits it provides, many of us would find that they scarcely balance the rapidly rising costs, even if we consider only the direct costs to ourselves. If one divides the distance driven by the average American in a year by the amount of time he has to work to earn the money to pay for the costs of this traveling, the average speed comes

out to be little more than walking pace.

A dramatically simple way to cut down one's dependence on the automobile is to choose a home near one's job, or vice versa. Failing this, many people could select their homes and workplaces for easy access by public transport. Eliminating the need for commuting by automobile not only saves time, money, and stress; it also greatly reduces the external costs which one imposes on others. These advantages will increase as the costs of operating an automobile increase, as they surely will in the future.

My own impact on the environment is less than half that of typical members of my social class. I have two children, I work for an environmental organization, and I live within walking distance of my work. This personal information is probably not of much interest to my readers, but I quote it both to point out that the measures I recommend can be adopted relatively easily, and also to introduce the idea that even these matters of basic lifestyle do not always have simple implications:

— The decision to limit a family to two children, which seemed socially and environmentally responsible 15 years ago, is no longer so clearly appropriate in the present-day context. With a two-child family becoming the norm, one should consider whether smaller families are now socially responsible. It is difficult to look ahead and make informed judgments about social conditions 20 years hence.

— Although living close to one's work provides enormous benefits (unimaginable to those who habitually commute), it limits one's choice of housing and therefore limits some of the other choices one might wish to make.

— Obviously not everyone could work for environmental organizations, even if they were so inclined. While environmental advocacy groups have an important and necessary role to play in present-day society, our problems might be solved more effectively by changes in values within environmentally destructive institutions. In my own case, I am not in a position to judge objectively the contribution of my work to society, but it certainly feels better than my previous job of training scientists for technological tasks whose social merits were at best doubtful.

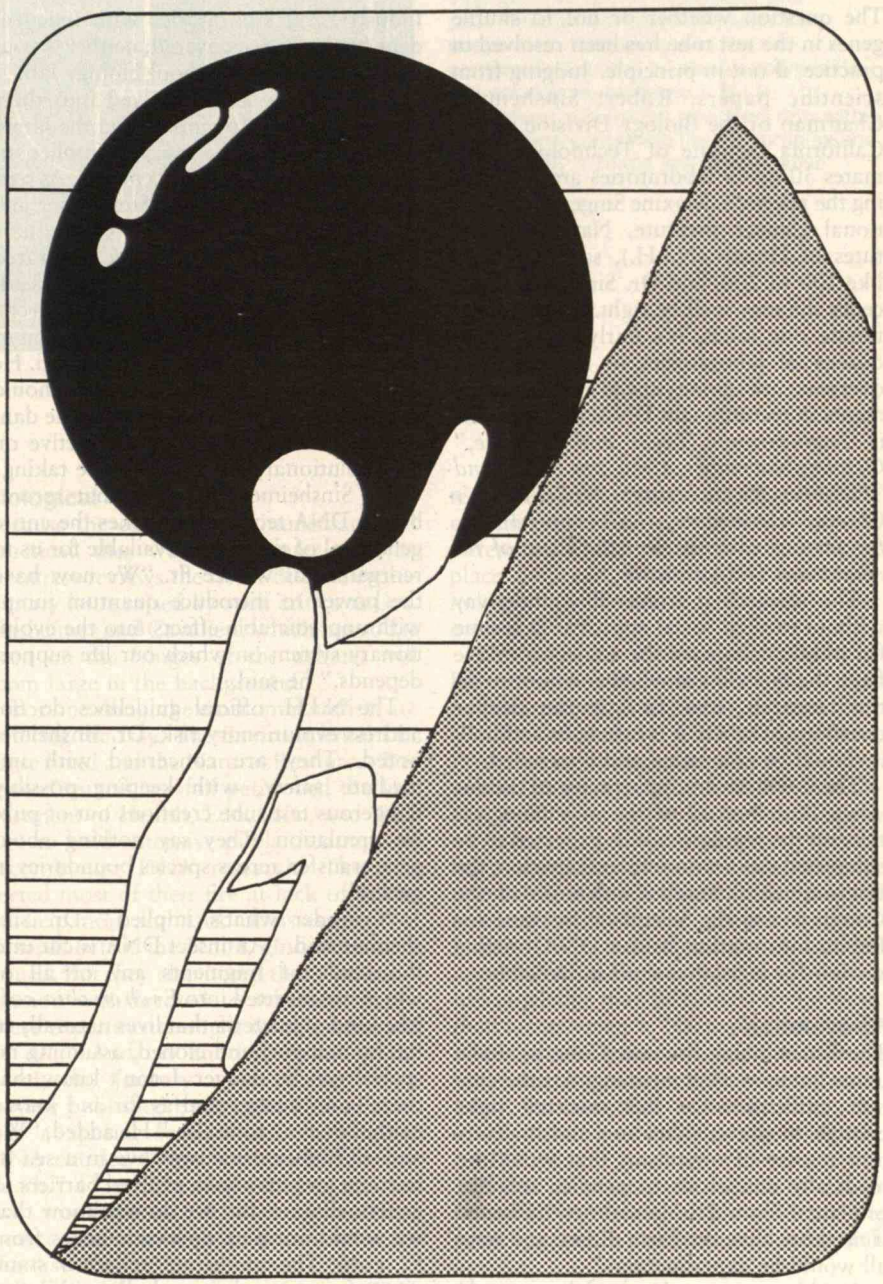


Illustration: Vaughn McGrath

Ian C. T. Nisbet is Associate Director, Scientific Staff, Mass. Audubon Society; he writes regularly for the Review.

Recombinant DNA: Time to Face the Facts

"The research is irreversibly underway without explicit social approval. It is time for public debate (on) . . . the deeper questions of where it is taking us and how it should be controlled."

Science Report by Robert C. Cowen

The question whether or not to shuffle genes in the test tube has been resolved in practice, if not in principle. Judging from scientific papers, Robert Sinsheimer, Chairman of the Biology Division of the California Institute of Technology, estimates 30 or 40 laboratories are conducting the research. Maxine Singer of the National Cancer Institute, National Institutes of Health (N.I.H.), says it's more like 100 to 200, and Dr. Sinsheimer concedes she may well be right. Whatever estimate one takes, it's fairly certain that dozens of laboratories in the U.S. and overseas are going ahead with experiments in recombinant DNA. *(See "Genetic Engineering: Threat and Promise," October/November, 1976, pp. 10-12, and "Genetic Engineering: The People's Choice," December, 1976, pp. 10-11, for further comment on the issue of recombinant DNA research.)*

The research is irreversibly underway without explicit social approval. It is time for public debate on the subject to move from the question of whether or not to do the research, and to ask the deeper questions of where it is taking us and how it should be channeled and controlled.

There will be an opportunity to do this when both houses of the new Congress take up the regulatory bills expected to be submitted this session. In anticipation, the Environmental Study Conference of the Congress and the Scientists' Institute for Public Information held a DNA briefing session for legislative staff in December.

Re-evolution

The issues facing the new Congress have immediate practical meaning: Are the current guidelines for this research tight enough to prevent creation and inadvertant release of organisms that would be medically dangerous to people, animals, or plants? Should the guidelines, tightened if need be, have the force of law and bind all would-be experimenters?

At this writing, the guidelines apply only to research funded or controlled by the Department of Defense, the Energy Research and Development Administration, the National Science Foundation, and N.I.H., which wrote them originally. Industry and laboratories with independent funds are not covered; neither is your neighborhood high school biology lab.

The briefing session delved into these matters, but it also emphasized the larger question of what the research implies for the evolution of life on this planet. As part of the briefing panel, Dr. Sinsheimer and Liebe Cavalieri of Cornell's Graduate School of Medical Sciences reiterated positions that have identified them as leading critics of recombinant DNA research.

"We are talking about a re-evolution of life on our planet," said Dr. Cavalieri. He thinks recombinant DNA research should be restricted to exploring its possible dangers until we have better perspective on the evolutionary risks we may be taking.

Dr. Sinsheimer explained that recombinant DNA technology makes the entire gene pool of the planet available for us to reorganize as we see fit. "We now have the power to introduce quantum jumps with unpredictable effects into the evolutionary system on which our life support depends," he said.

The N.I.H. official guidelines do not address evolutionary risk, Dr. Sinsheimer noted. They are concerned with immediate safety, with keeping possibly dangerous test tube creations out of public circulation. They say nothing about gene transfer across species boundaries in general.

"Consider what's implied," Dr. Sinsheimer said. "An insect DNA is cut into thousands of fragments any or all of which are inserted into *Escherichia coli* [the kind of bacteria that lives naturally in the human gut] and cloned, assuming no special genetic danger. I don't know that there is no danger and as far as I know, neither does anyone else." He added, "We and all higher organisms live in a sea of bacteria and may have evolved barriers to genetic disease. But we do not know that we would not pick up exotic genes from *E. coli*. The guidelines reflect a static view of nature as being wholly within our control in these matters." He would confine experiments that carried any risk of such dangers to a few special national laboratories with especially tight safety precautions.

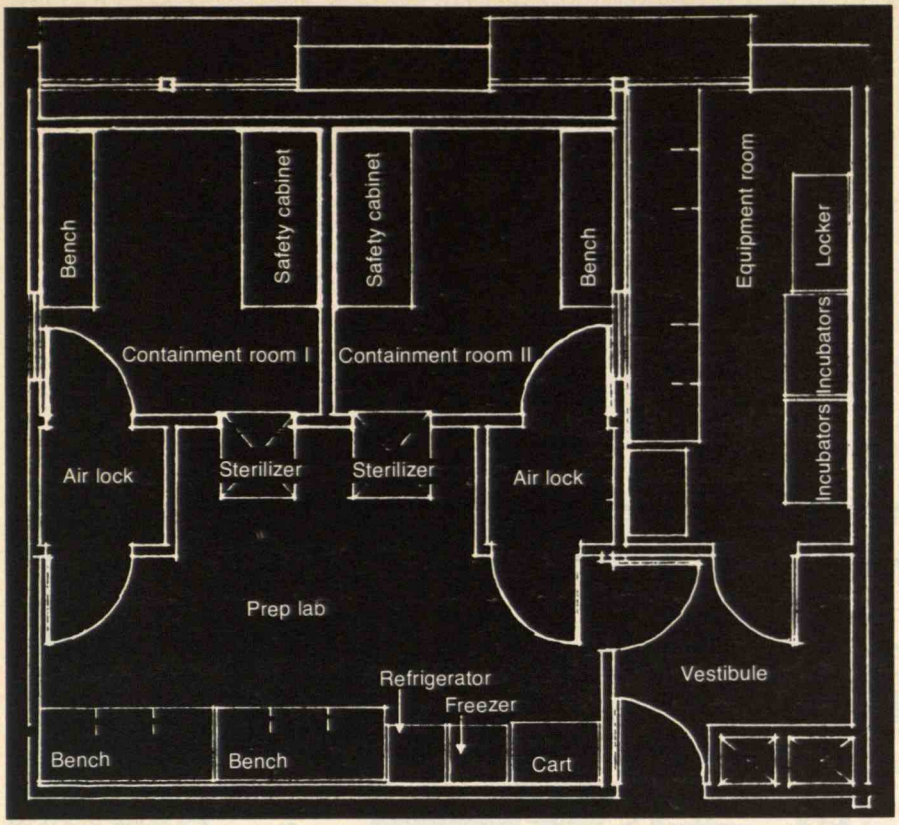
Vague Fears

Dr. Sinsheimer readily admits that his evolutionary concerns aren't shared by many of his colleagues. Dr. Singer and Robert Pollock of New York State University at Stonybrook, the other two members of the panel assembled for the legislative briefing session, made it clear that most biologists are far too excited by the power of the new research techniques to do much looking before they leap ahead with it.

One must remember, Dr. Singer said, "We do not, in fact, know that any of these agents would be hazardous. We are always dealing only with a potential that some of them might be hazardous." It would be unfair, and unrealistic, to expect biologists to give up what to them is one of the most important research tools since the microscope for the sake of vague fears. Dr. Pollock noted on the evolutionary score that it is not at all clear "that breaching a species barrier is, in itself, a hazard." But he said it is abundantly clear that "there is no risk-free route to new biological knowledge." Even to refrain from the research is to run the very real risk of denying humanity knowledge that could confer great benefit.

Briefly, biologists have this new capacity: enzymes called restriction endonucleases act as chemical scissors that can cut up DNA molecules, the molecules that carry the blueprints of living organisms. Genes can be snipped out of the DNA of one species and, using still other types of enzymes, welded into the DNA of another species. Specifically tailored strands of DNA can then be inserted into bacteria or into cells of higher organisms. There, the DNA can reproduce along with the cells.

The technique may make it possible to design bacteria to produce quickly and cheaply large amounts of such valuable chemicals as insulin, or to tailor-make plants that fix their own nitrogen. However, the immediate benefit to biologists is the power to get at specific sections of DNA and read them. Scientists can begin to crack open the puzzle of what lies between genes on the DNA strand: for example, the codes for starting and stop-



What does a laboratory for recombinant D.N.A. experiments look like? The plans at the left are recommended by the Biohazards Subcommittee of Princeton's University Research Board; they are for a laboratory which will be "significantly more secure" than required by the National Institutes of Health for P3-level experiments. Princeton's special features not required by the N.I.H. include: a two-level negative pressure system (the preparation room is under negative pressure relative to the corridor and the containment room is under negative pressure relative to the preparation room); a separate equipment room, also under negative pressure with respect to the corridor, in which all reagents will be stored and prepared and in which bacterial and viral cultures will be incubated; and pass-through sterilizers between the preparation laboratory and the two containment rooms in which experiments will actually be performed. N.I.H. regulations require the sterilizers only within the building containing the P3 complex and require only a single level of negative pressure.

ping gene action.

Biologists, whether in universities or in industry, would not be easily persuaded to accept restrictions on such a tool, except where potential dangers are fairly clear. Thus the N.I.H. guidelines forbid experiments with known pathogens and experiments to enhance bacteria's ability to produce poisons or resist drugs. Otherwise, they allow anyone to recombine genes provided they do so under varying degrees of physical containment, scaled to match the presumed degree of potential hazard, and sometimes coupled with a form of biological birth control. Some of the precautions specify use of EK-12, a strain of *E. coli* bacteria genetically weakened to reduce its chances of surviving should it escape.

Many biologists do feel some concern about these guidelines, even though they think recombinant DNA research should go ahead. As Dr. Singer explained, the guidelines probably should be extended to cover all experimenters, even in industry, and given the force of law. Perhaps they could be made more stringent. At Princeton University, for example, a study recommends somewhat stricter containment rules than N.I.H. specifies for research at that university. But Drs. Singer and Pollock are also right to say that anything significantly more restrictive than the present guidelines just wouldn't be acceptable to most biologists, let alone to industry.

Biological Politics

Because the concerns are immediate and practical, they will hold center stage as Congress reviews the issue. But the evolutionary issue raised by such critics as Drs. Sinsheimer and Cavalieri, which has so far been on the fringes of the debate, will loom large in the background.

For one thing, the environmentalists are entering the fray. The Environmental Defense Fund and the Natural Resources Defense Council last fall petitioned the Department of Health, Education, and Welfare to hold extensive public hearings on recombinant DNA research. They directed most of their fire at lack of public participation and lack of assessment of hazards before the N.I.H. guidelines were issued. But they also noted that "little discussion was devoted to whether or not these experiments ought to be performed *at all.*" And, as another straw in the wind, the January issue of *Not Man Apart,* published by Friends of the Earth, has a special section on recombinant DNA entitled "New strains of life — or death." That is the kind of language that has impassioned debates on nuclear power, and it is likely to do the same for the discourse on recombinant DNA.

Public debate on recombinant DNA will not be confined to the halls of Congress. It will reverberate and grow across the nation as more and more people wake up to the fact that the research is going on in their own home towns. It will undoubtedly be as emotional and ragged as the nuclear power hassle. But there is a major difference. This time the debate is taking place before a revolutionary new technology has become entrenched in our economy.

This will be a prolonged, uncomfortable experience for researchers and their administrators. But like it or not, they should welcome it. Clifford Grobstein, Professor of Biology and Vice Chancellor of the University of California at San Diego, points out in the December 10 issue of *Science* that the importance of arriving at a social consensus on this awesome research transcends the importance of the research itself. "If the hazards of recombinant DNA technology prove unmanageable but concealed, the rate of advance of knowledge may be slowed by far more than inconvenience," he explained. "If the whole process goes well, science, technology, and the world will breathe more easily, knowing that on this issue they live openly and honorably, each with the other."

If that comes to pass, the rise of recombinant DNA research will mark a turning point for science policy as well as for biology.

With this contribution, Robert C. Cowen begins a new series of reports for Technology Review *(see page 3).* *He is Science Editor of the* Christian Science Monitor.

Trend of Affairs

Trends This Month

Crimestopper's Notebook: Look for all sorts of new and dynamic uses for Citizen's Band and other mobile communications devices over the next 20 years. Muggers won't have a chance when each person is equipped with a private pocket radio, and hijackers will fade fast when each trucker is equipped with his own satellite-relayed radio communicator. (Illustration: Judy Richland)

Breaker 1999

The enormous growth in popularity of Citizen's Band radio is only a step toward the ultimate future of mobile communications, according to Harold Staras of RCA Laboratories. At the National Telecommunications Conference this winter, Dr. Staras conducted a tour of the possibilities he and his colleagues foresee.

"Extrapolating the trend of current uses for CB, I can foresee portable and even pocket-sized, short-range CB radios at high frequencies which can be used in urban environments to call for help in case of fire, heart attack or mugging," said Dr. Staras.

Since high-frequency radio waves tend to propagate down streets, said Dr. Staras, it may even be possible to develop a locating system for the call for help, by setting up "electronic signposts" along city streets to determine the source of a transmission.

Fleets of taxis, buses, delivery vans, or police cruisers could also use automatic vehicle location systems which would depend on radio signals. Electronic signposts would automatically contact a vehicle's radio, which would relay to headquarters the signpost identification number, the vehicle's identification number and accumulated distance since passing the signpost. One test of such a system is already being conducted by the U.S. Department of Transportation in Los Angeles, he noted.

The average vehicle might also carry an "electronic license plate," said Dr. Staras. Such plates could be used as part of an automatic toll collection system, or a check-in system for rental cars, or for law enforcement. The electronic license plate would consist of a "label" on the vehicle which would be read optically, or by a microwave or other transponder, by an interrogator along the vehicle's path. This interrogator would transmit the identification to a control center.

Houses and automobiles of the future may also feature a radio lock, which would substitute a microwave "label" for a physical key. The label would consist of a printed circuit antenna which contains a coded digital message. When the label was held in the vicinity of the radio lock, the lock would emit a weak, short-range microwave signal, which the label would reradiate modulated into the code signal, and the lock would spring open. Such a lock would be tamperproof because the locked door would present no keyhole or other opening.

The proliferation of communications satellites also offers the possibility for better mobile communications, said Dr. Staras. Direct communications with long-haul trucks and buses via satellite could be cost-effective before the end of the century, he predicted. The only real operational constraint he sees would be the requirement that a driver desiring to radio home base pull over to the side of the road to manually aim his rooftop satellite antenna at the overhead satellite. If the base were trying to reach the vehicle, a narrow-band digital signal could alert the driver to contact the base. The average truck or bus could be equipped for such a system for about $2,000 calculates Dr. Staras, and the rental charge for the use of one satellite voice channel would be about $40 per month. However, since the average truck or bus company could not afford its own satellite, a third-party entrepreneur will have set up the system.

Although the technology for such mobile communications is either in hand or just over the horizon, Dr. Staras stresses that all may not come to pass. In his paper prepared for the conference, he issued what all futurists would agree is an excellent technique for face-saving.

"The reader is requested to remember those predictions made here which do materialize and to forget about those which fail to do so." — *D.M.*

Uncle Sam Puts Telecommunications on Hold

The visionaries who spin tales of futuristic worlds where we could shop, learn, and pay bills via cable television and supercomputer telephones are wrong.

Those services could be available today if it weren't for governmental regulatory ineptitude, according to telecommunications experts meeting at the National Telecommunications Conference this winter in Dallas. The engineers and industrialists cited both sins of omission and commission on the part of the government in a symposium to examine the realities of improving telecommunications for the home.

"There isn't one person who gives a damn in Washington about the telephone needs of the average person," asserted consultant C. Raymond Kraus. "It is the philosophy in Washington that the competitive marketplace will automatically provide the average citizen's needs. Not so; it provides only specialized business requirements and ignores the common person whose requirements are not met by the existing services."

Besides improving basic telephone service, especially in outlying areas, Mr. Kraus called for studies on two services which could greatly extend the usefulness of the average telephone — "Voicegrams" and "Faxgrams." Voicegram service would allow the average user to send a quick, one-way message to any telephone. Faxgram would be a facsimile service between key post offices, using the phone lines, which would allow an exact copy of a submitted page to reach the person by mail the day after it was sent. These two services, said Mr. Kraus, could fill the enormous gap between telephone service and the mail.

Cable television also has a fund of

technology available, but is hamstrung by government regulation, said Michael Jeffers of Jerrold Electronics Corporation. Devices already exist to control the television signal to individual sets, and to freeze television frames and allow home response. But to institute home shopping, educational, and other services, the cable companies need a large base of subscribers to make the services economically feasible. A large subscriber base would be needed because a fairly low percentage of subscribers would be interested in services other than entertainment, said Mr. Jeffers. The government, he said, has restricted entrance of cable TV into the larger urban markets where that subscriber base could easily be developed.

Dean Gillette, an engineer with Bell Telephone Laboratories, agreed that current equipment is perfectly capable of handling remarkable improvements in service.

"A plain old telephone channel will deliver data at rates two orders of magnitude faster than the human brain can assimilate it; but we are just beginning to explore the ways in which telephone networks can connect people and computers to provide new kinds of services." Mr. Gillette emphasized the need to rally community support behind new services, rather than to expect government legislation of new technology.

Setting boundaries between unregulated and regulated telecommunications services will present a special problem to government agencies, according to William H. Melody of the Annenberg School of Communications, University of Pennsylvania. The traditional policy of viewing communications networks as necessary monopolies will have to change as entrepreneurs begin focusing their efforts on new ways to use the old systems. Such companies will own little or no facilities of their own, said Dr. Melody, but will provide expertise to manage the new telecommunications systems. And it will be impractical to regulate the profits of such new companies based on a return on investment, because they will have little investment in physical facilities.

"The established telephone companies, led by the Bell system, can be expected to resist change at every step of the way with their litany of responses designed to prevent or limit competition," said Dr. Melody. According to him, the government will by no means lead the way to new telecommunications services with its policies; rather the new facilities and services will force regulation to catch up to new realities.

As it is, too much government regulation at all levels of the industry is piling additional cost burdens on the operation of new services, said Paul Polishuk of Horizon House International. While the revenues from cable TV are potentially enormous, he said, the number of households served by cable systems appears to be levelling off, because of the stifling regulatory environment and a lack of economic justification for the systems. Dr. Polishuk joined the technologists on the panel in decrying the lack of leadership and management in government regulatory bodies:

"Don't hold your breath if you're looking for the government to help overcome even the smallest barrier to new telecommunications services," he warned. — *D.M.*

How to Teleperson

Perhaps videophones and other such advanced communications gadgetry seem like great ideas, but they may not be much better at the communications job than more prosaic voice communications.

Laboratory experiments in how well people communicate to solve problems have revealed some quite unsuspected strengths and weaknesses in the power of various media, according to Alphonse Chapanis of the Johns Hopkins University Department of Psychology. He described his findings at the National Telecommunications Conference this winter.

Dr. Chapanis conducted tests in adjoining rooms connected by microphones, loudspeaker systems, teletypewriters, video cameras and monitors, and devices for duplicating handwritten messages and drawings. In his experiments, Dr. Chapanis assigned test subjects a problem to solve cooperatively, and for each problem, restricted the subjects to certain types of communications between the rooms. For instance in one problem, a "seeker" subject is given an electronic panel and a set of wires with clip ends. The object of the exercise was for the "source" subject to communicate to the seeker the correct wiring diagram to build a given working circuit. In other experiments a group of subjects was asked to settle a conflictive problem among themselves using given communications media. One such problem was to rank in order the ten most important issues facing the U.S. today. Another problem, to negotiate for reducing the school's athletic budget, with each participant cast in the role of captain of a team playing one of the school sports, vying for a piece of the budget.

After testing about 20 sets of such problems, Dr. Chapanis discovered a number of generalizations that could help guide those who would develop communications networks. The provision for voice communications seemed to be a key requirement for solving problems quickly, he found. In comparisons of the mean times for solving problems using the various combinations of visual, audio, and written modes, the only statistical difference occurred between those that included voice links and those that didn't.

Face-to-face communications did not help significantly in solving problems, discovered Dr. Chapanis. Being able to see the other person did not appear to give an advantage over voice-only communications.

Modes of communications that have a voice channel are much wordier than those that do not, he discovered. Also, being able to see the other person, thus taking advantage of gestures and body language, seemed to increase the number of words used in solving problems, not decrease it.

Dr. Chapanis tested both high school and college students in his laboratory, and found that both spent the same percentage of time performing the various kinds of actions in communicating — sending, receiving, making notes, waiting, etc. However, the college students performed all the actions faster and solved the problems quicker.

One might assume that the more people involved in a conference the more an individual might restrict his verbal output, to allow things to proceed more quickly. However, Dr. Chapanis discovered that the number of words in a conference increased linearly with the number of conferees. "It was as if each person had a fixed number of things to say that he had to get off his chest," said Dr. Chapanis.

In one group of experiments, Dr. Chapanis attempted to determine how well subjects could communicate the circuit diagram simply by drawing. His conclusion, perhaps only half in jest, was that one picture was not worth a thousand words, but only about a dozen. — *D.M.*

ENERGY

Plutonium and the Nuclear Future

Buoyed by the success of nuclear power in six state referenda last November, the U.S. nuclear industry has now turned its attention toward solving what it calls the "plutonium problem" — the issue of completing the nuclear fuel cycle by recovering and using plutonium from the spent fuel from today's reactors.

It's an issue fraught with uncertainties.

The argument is that plutonium could substitute for about one-fifth of the uranium required in conventional fission reactors as now operated and — with minor changes in those reactors — could replace some 40 per cent of present uranium needs. Professor B. I. Spinrad of Oregon State University believes that a reactor fueled on plutonium would be more reliable than today's all-uranium-fueled reactors, whose availability on average was just under 75 per cent in 1975.

But reactor-grade plutonium can be used for nuclear explosives, and everyone agrees that no great technical sophistication is required. Many observers remain

adamant that the only safe plutonium is that in the impure state, as it is now accumulating in spent reactor fuel. Others propose that both national and international safeguards can be adequate and that the risk is therefore minimal. *(For a full discussion of this problem, see the article by Victor Gilinsky, Commissioner of the U.S. Nuclear Regulatory Commission, on pages 58 to 65 of this issue.)*

The economic incentives to recycle plutonium depend on the number of reactors in operation and the cost of "virgin" uranium for them. Nothing is certain about either.

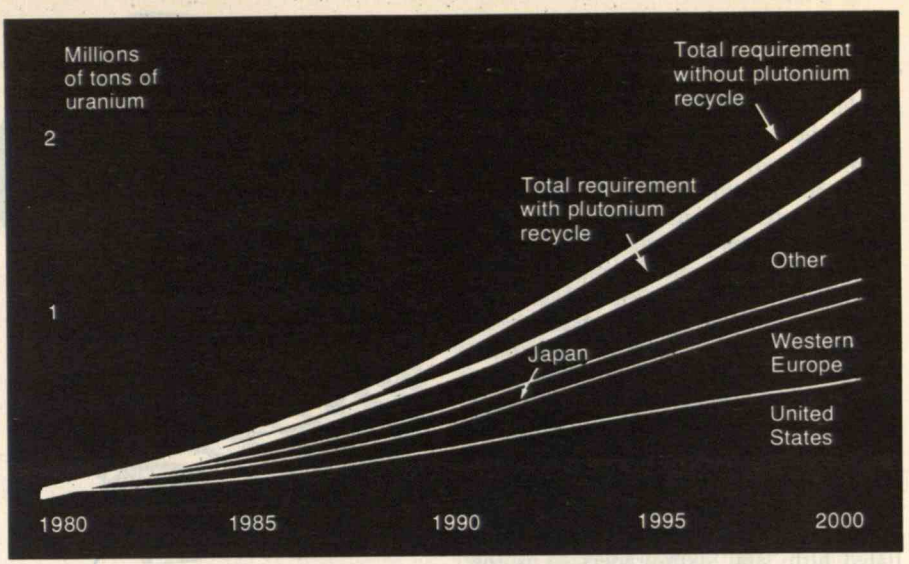
Despite the referenda results, it is naive to think that the nuclear industry's frustrations with regulatory delays are about to be resolved. One-third of the electorate in those referenda were opposed to nuclear power, and — as Rudolf Rometsch of the International Atomic Energy Agency reminded the American Nuclear Society last fall — "it is harder to unscare people than to scare them." Irwin C. Bupp of Harvard University shares that view, adding that opposition to nuclear power is operating in "an extraordinarily receptive administrative and judicial environment."

According to the most optimistic estimates, some 100 gigawatts (1 gigawatt = 1,000 megawatts) of nuclear power will be in use in the U.S. in 1980, and arrangements now exist for an additional 100 gigawatts of capacity by 1985. If 20 new plants are ordered per year — a very high rate indeed — for completion between 1980 and 2000, the nation's nuclear capacity in the year 2000 could be 600 gigawatts. That's "the flat-out limit that we can conceive, if everything goes right," Professor Bupp told an M.I.T. seminar last fall.

But even without the question of public acceptance, and on economic grounds alone, Dr. Bupp has no confidence in that scenario. If he were about to invest in new power generation facilities in New England today, he would be "on the fence" between coal and nuclear. There is just too much uncertainty in the price of coal, the time and capital required to build a reactor, the cost of that capital, and the cost of nuclear fuel ("You just don't know what the nuclear fuel cycle will look like," he said).

Another problem with the "flat-out" scenario was raised by Professor George D. Sauter of the University of California (Berkeley) Lawrence Livermore Laboratory before the American Nuclear Society: to build so much nuclear capacity would require large amounts of energy. "At least 30 per cent of all the power produced by the new system would have to be fed back into further plant construction to maintain the expansion of the system," he said.

If Dr. Bupp is wrong and the "flat-out" scenario turns out to be right despite the issue raised by Professor Sauter, the U.S. will need prodigious amounts of nuclear fuel — about 1 million tons cumulative by the year 2000. If world nuclear development proceeds apace, the total demand may well have reached 3.8 million tons. World reserves may be as much as 4 million tons, and at first glance this seems "an adequate resource position," says Robert D. Nininger of the Energy Research and Development Administration. But nearly half of the total estimated reserves remain to be confirmed, Dr. Nininger told the Atomic Industrial Forum in November, and there is a long lead time between confirmation and production. Dr. Nininger's conclusion is that the price of uranium will start to climb in the 1980s and that, without plutonium recycle, uranium supply "may well become a constraint that must be considered in making future nuclear power growth forecasts."



If, as the U.S. Energy Research and Development Administration forecasts, the non-Communist nations have 1,540 gigawatts of nuclear generating capacity on line by the year 2000, cumulative virgin uranium requirements will be over 2.25 million tons by that date. If spent fuel is reprocessed and its unfissioned uranium and plutonium recycled, the total requirement would be only 1.9 million tons. Against these figures must be placed E.R.D.A. estimates of uranium reserves in the non-Communist countries which can be produced at $30 or less per pound of uranium oxide: about 1.86 million tons, with a similar amount likely to be added through exploration by 1985. Robert D. Nininger, Assistant Director for Raw Materials in E.R.D.A.'s Division of Nuclear Fuel Cycle and Production, told the Atomic Industrial Forum late last fall that uranium "may well become a constraint that must be considered in making future nuclear power growth forecasts."

The probable cost of reprocessing is not yet known. Allied General Nuclear Services has invested $250 million in the only U.S. fuel reprocessing plant, now nearing completion. But it cannot go on line until president Ford's surprising request of late October for a new evaluation of the security and economics of reprocessing is fulfilled and acted upon, and President Carter's attitude toward nuclear development is unclear. Under these conditions additional reprocessing capacity can hardly look like a choice investment opportunity for U.S. business.

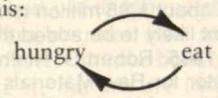
Advocates of plutonium reprocessing are adament. They project a scenario of U.S. energy shortages for 1985 and 1990, noting that consumption is now rising again after two years of recession and "energy crisis," that U.S. oil and gas will by then be much more nearly depleted, that facilities for mining and moving coal will be inadequate, and that uranium may be scarce. Such a "worst-case" scenario portrays "a time of troubles," says William O. Daub of the Washington firm of LeBoeuf, Lamp, Leiby, and MacRae — a time when we would be glad enough to ease uranium shortages with recycled plutonium at almost any cost. But that option won't be available unless the job begins now: "a serious reprocessing effort is a major undertaking," a capital investment approaching $1 billion, Mr. Daub told the A.I.F.

Sarah Miller, Washington Editor of *Nucleonics Week*, reports (in the *New York Times*) that at least one E.R.D.A. official looks at the same data and reaches a different conclusion: reprocessing "will turn out like oil shale — profitability always just around the corner but you never quite get there." And Ms. Miller says the possibility of eliminating plutonium recycle from the nuclear fuel cycle —in other words, permanently disposing of high-level reactor waste without first recovering its plutonium — is "suddenly being considered seriously for the first time." — *J.M.*

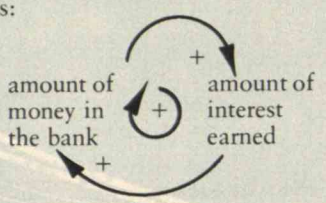
The Arrow Game

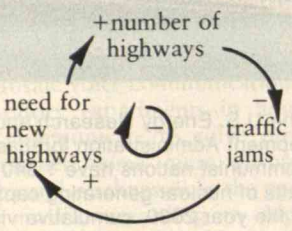
If systems thinking based on concepts of dynamic feedback is a useful way for adults to understand how things work and the interventions which will make them work better — industrial dynamics, urban dynamics, world dynamics — then it should be useful to 12-year-olds as well.

Nancy Roberts, Research Associate in Jay W. Forrester's System Dynamics Group in the Sloan School of Management, defines a dynamic feedback system as "an ongoing set of relationships in which the output of an action taken by one person or group eventually has an effect again on that person or group." The simplest example — with which she initiated fifth- and sixth-graders — is the "hungry-eat causal-loop": "being hungry causes me to eat" is shown in a diagram like this:



Then comes the question of direction: a plus sign was used to indicate positive feedback — "the variable at the head of the arrow changes in the same direction as the variable at the tail of the arrow" — and a minus sign for negative feedback. And finally, the students determine the direction of the system as a whole, described as positive ("a positive feedback loop is one that continues going in the same direction, eventually exploding") or negative with a plus or minus sign enclosed with a tiny arrow. Here are some examples:





After a series of such exercises, says Ms. Roberts, the children in her class were able to explain the dynamics of systems they talked about by drawing their own causal-loop diagrams; they had in fact learned this way of thinking about their problems.

And the teachers who worked with Ms. Roberts came to recognize "the interdisciplinary nature of dynamic feedback systems thinking and its applicability to every aspect of the curriculum": a science teacher took the system into his classes, and a language arts teacher decided to explain book characters in terms of their perceptions of themselves as parts of such systems.

It's a pilot model which shows how to "broaden significantly the audience for understanding and potentially using management science thinking and tools," says Ms. Roberts. — *J.M*

The Oil Crisis

One aspect of the oil crisis, as explained by an economist, was the starting of a "vicious circle." This vicious circle was begun by agreements made by the Arab oil producing countries in 1971 called the Teheran and Tripoli Agreements (named for the cities in which the meetings were held). Here these countries agreed to raise the price of oil. The rise in oil prices meant that these countries then made more money. They made so much more money that they could not possibly spend it all. Realizing this, these countries decided not to produce as much oil. They knew that eventually their oil supply would run out so they might as well make it last as long as possible.

Because there was less oil being produced in the world, and more oil was needed every day, a scarcity of oil developed. This scarcity of oil forced the oil prices to go up even higher, continuing the "vicious circle."

1. Draw a feedback diagram showing the "vicious circle" that this economist points out.

2. Label each arrow with either a + or −.

Can you write a diagram which describes "The Oil Crisis"? It's one of the tests given by Nancy Roberts to a class of sixth-graders learning to think in terms of dynamic feedback systems — the same kind of analytical method that has led Jay W. Forrester, Germeshausen Professor of Management at M.I.T., to industrial dynamics, urban dynamics, and world dynamics. Ms. Roberts' diagram of "the Oil Crisis" appears at the bottom of page 18.

How to Expose the True Cost of a Car

What is the true cost of operating an automobile — to the owner, to the owner's neighbors, and to the state?

Most of us figure our ownership in terms of our out-of-pocket expenses for gasoline, maintenance, payments and depreciation, insurance, and auto taxes — plus some small share of other taxes. For "environmentalists" intent on a complete accounting, the answer is all of these plus the high "social" costs of such externalities as pollution, noise, congestion, and urban sprawl.

Under the "most-of-us" formula, we elect to build a new highway when surveys tell us that the savings it promises to users are greater than the expense of construction. But many of us are now taking a second look, trying to incorporate into the "cost-benefit" decision some of the externalities as well as the direct costs. Two problems arise: how to put a dollar value on "social" costs, and how to anticipate the effect of the highway on the demand for it — hence, how to estimate future "social" costs and benefits.

Attempts to estimate current "social" costs have led to averages for urban roads at rush hours ranging from 18 cents (1961) to 25 cents (1974) per mile. These are averages: the 1974 figure draws on some roads on which "social" costs are as high as $1.40 per mile. Clearly, says William C. Wheaton, Assistant Professor of Economics at M.I.T., "American highway investment in urban areas results in 'social' costs that far exceed . . . present taxes and charges on American driving."

Seeking to rationalize these costs, Professor Wheaton has now tried a new formula for assigning both present and future costs — all of them, real and "social" — to the 100 million motor vehicles in the U.S. His mathematical model distinguishes between urban highways, where "social" costs are high, and rural highways, where they are lower, and between driving at rush hours (high costs) and at off-peak times (lower costs). The result is

expressed as a "toll" per unit of driving — the amount each of us should pay, in addition to the direct expenses for the vehicle and fuel and insurance and taxes which are now familiar to us, to cover the full "social" costs entailed in the present and future use of our automobile.

That toll works out to be, on average, 50 cents per gallon of fuel we use. Professor Wheaton would like to have that amount added to the price of fuel as a tax. He admits that this would not represent an assignment to each driver of the "social" costs of his use of his car on the basis of the roads he uses and the times of day he uses them; that's simply too complicated. But "the true 'social' costs of driving can be at least partially priced with the appropriate uniform tax," he says.

And Professor Wheaton is satisfied that "the failure of past policymaking to adopt [such a measure] undoubtedly justifies the view that the sprawling, auto-dominated character of American cities does represent a misallocation of resources." — *J.M.*

NEW TECHNOLOGY

Wind Over Water

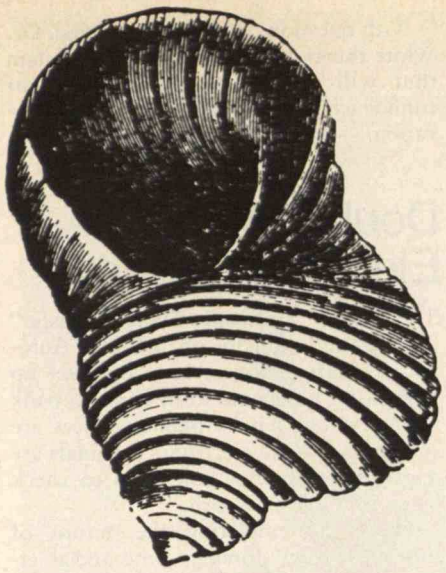
For over 70 years, engineers and oceanographers have accepted a model to explain the effects of wind on ocean currents, and designed oil rigs and breakwaters accordingly. Now that wisdom is being challenged, and the design principles for offshore structures may have to be revised.

The challenge comes from Ole S. Madsen, Associate Professor of Civil Engineering at M.I.T. Professor Madsen's point is that the force transmitted from wind to water below the surface depends more on frictional effects than was previously thought.

The earth's rotation modifies the response of sea water to wind — the so-called "Coriolis effect." Allowing for this phenomenon, the old model postulates about a 45 degree angle between the direction of wind and surface water for the middle latitudes. Below the surface, the decreasing speed and changing direction of the current can be visualized to follow the shape of a shell: for each "layer" below, the current is a bit more to the left and its strength slightly less.

Dr. Madsen's idea leads to a model with a smaller angle between wind and current and with underwater currents which wind down the coil faster. Translated into physical terms, this means a sharp decrease in current force close to the surface. For example, a wind-driven current may have only about ten per cent of its surface strength at one meter of water ten meters deep. The conventional model puts that ten per cent strength close to the bottom for water of the same depth.

Verifying Dr. Madsen's model in the ocean is difficult and costly. An obvious way to gather the needed data is to attach current meters at various depths to a fixed structure such as an oil platform, with the goal of understanding the current due to wind. But the wind also inevitably causes waves which have forces of their own. How can this complex series of interactions be unwound, so that each can be fully understood? The very complexity of ocean dynamics which makes theories of wind-induced currents of such great interest may also make them unproveable. — *Debra Knopman*



The velocity and directional effects of wind on ocean currents can be visualized to follow the shape of a shell: for each "layer" of water below the surface, the current deflects a bit more to the left and its strength diminishes. A new model of this effect predicts a smaller angle between wind and current direction, and hence a thinner, less coiled "conch." If the model proves correct, design principles for offshore structures may have to be revised.

Innovation: Nothing to Fear but Fear

Innovation feeds on success.

Robert N. Noyce, Chairman of the Board of Intel Corp., has launched highly successful enterprises in semiconductors and microcomputers. He remembers only that "I was doing what I wanted to." He had no real fear of failure; his only sense of risk was "not being able to fulfill the goals I set for myself." Indeed, Dr. Noyce is convinced that fear is a poison for innovation — a negative pressure which makes research and development people cautious and impotent.

The way to achieve a positive environment is to be confident of success and to reward it generously, Dr. Noyce says. Instead of a retirement plan, Intel Corp. has a generous stock option plan. He's confident — bullish for his company and his industry. Four to one, says Dr. Noyce, a microcomputer will be standard equipment in every American automobile built after 1980, and he expects to see them in all new television sets — for TV games — by 1978.

"An enormous opportunity for new innovation," Dr. Noyce told an M.I.T. seminar in New York this winter, and the only cloud on the horizon, he said, is the attitude — he fears it is increasingly abroad in the land — that profit is a dirty word, that there is something immoral about financial incentives to success.

To James M. Utterback of M.I.T.'s Center for Policy Alternatives, Dr. Noyce sounds a little too brash and confident. The semiconductor industry, in which Dr. Noyce's firm is a brilliant star — almost an exploding nova — is in transition, says Dr. Utterback; it is somewhere between youth and maturity. Dr. Utterback identifies two broad patterns of innovation for the youthful and mature industry:

— Broad, sudden change — a discontinuity which leads to an unconventional new product and changes the relationship between producer and user. This kind of change characteristically happens in small companies and new industries — like Dr. Noyce's in its early years — which are not burdened by the inertia of large capital investments and large responsibilities to workers and stockholders.

— Quiet, incremental change which tends to affect process more than product. This kind of innovation results from concentration not on opportunities but on problems and bottlenecks; the driving force is cost-saving. The goal is typically to increase the productivity of existing capital, not to find opportunities for new capital; and Dr. Utterback associates this kind of innovation with mature firms whose product lines are established and whose competitive position depends on lowering price or improving quality.

To managers of industries in both categories who are looking for new worlds to conquer, Professor Eric von Hippel of the Sloan School of Management at M.I.T., offers this unconventional advice: ask the sales department. Someone your salespeople know has probably already written the specifications for a successful new product for you. Customers for electronic instruments for example, turn out to have modified instrument-makers' products and devised add-ons, and it remains only for the instrument-maker to perfect those modifications and add-ons to create a whole new product line. The problem, says Professor von Hippel, is to make salesmen function as both "output devices" — their usual role — and "input devices."

For executives of firms embarking on new products, a word of warning from Edward B. Roberts, Sarnoff Professor in the Sloan School: your chances to

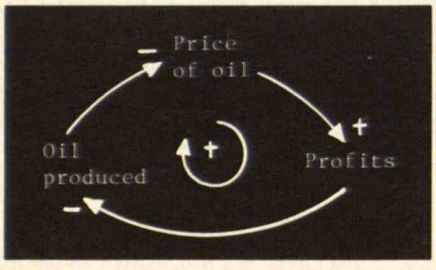
influence the course of development come early, before the basic decisions are made and when lots of options are open. As development proceeds and manufacturing and marketing plans are set, the executive's options for influencing the outcome of a new product decrease steadily.

But most executives do it wrong, says Professor Roberts; they devote time and energy to new products only at the stages of manufacturing and marketing. By then the crucial decisions have all been made — a "strategic misallocation" of management time, he says.

Can anyone predict success or failure in this risky business? Professor George R. White of Harvard Business School — he's on leave from his post of Vice President–Product Planning at Xerox Corp. — thinks so. After looking at the history of a few crucial innovations — the transistorized portable radio (1956), the transistorized automobile radio (1957), the transistorized color television — Professor White has assembled a list of questions for executives to ask about every new product he's thinking of marketing:

— What constraints on the market will the innovation release?
— What new constraints will it add?
— What additional technology will be needed to make the innovation work?
— Can still more new technology be added to make the market even larger?
— Will new business operations — marketing methods, sales territories — be involved?
— Will the innovation truly increase demand? Can the market expand?
— Will it save someone money?

For example, according to Dr. White's analysis the transistorized portable radio had almost everything going for it. It was a smaller, lighter product (with lower fidelity, but who cared?) when those were exactly the characteristics sought by consumers; and in addition it would be less costly than its predecessor. The transistorized auto radio could promise cost reductions, but the volume of its market hinged not really on the appeal of the innovation but on something over which its inventor had no control at all — the number of new cars built. The transistorized color television promised relatively very little to consumers — and its market penetration took ten years longer than the others.



"The Oil Crisis" — see page 16.

With questions such as those listed, Dr. White thinks he has an analytical system that will assure the environment of confidence that will breed the next innovation. — *J.M.*

Doubts About Electronic Money

The era of "Electronic Funds Transfer" (EFT) is undoubtedly on its way. Automated clearing houses have been set up to transfer payments from bank to bank via computer; pay-by-phone services are springing up; and electronic terminals are appearing in banks and stores to check credit and dispense cash.

Those contemplating the future of this technology foresee some social effects which will at least require careful lawmaking and at most cause serious problems. At the National Telecommunications Conference in Dallas this winter, experts in the field examined the cloudy future of EFT.

The possibility that electronic cash might zip through the consumer's fingers faster than hard money worries Gordon B. Thompson of Bell Northern Research. Mr. Thompson wondered whether the combined impact of responsive cable TV and electronic money might tempt the shopper into impulsive video-shopping.

"The hard sell one sees on television could be directly coupled to a purchasing act," said Mr. Thompson. "By just inserting a credit card in the appropriate slot and pressing a button, the latest kitchen gizmo is on its way to the viewer's home, and his bank account will have been automatically adjusted."

"Letting a prospective customer browse through an electronic catalog will be far less effective in terms of the seller's cost/benefit than mounting an intensive television advertising campaign coupled to an instantaneous response and funds transfer system. The old 'circus hawker' will be rekindled in electronic form."

Electronic auctions and media gambling could also be possible with the combined responsive cable TV/EFT systems, said Mr. Thompson. There could be ten-second lotteries, with painless payments made by simply slipping a credit card into the slot.

"EFT and general purpose response systems could combine to efficiently search out and bilk every compulsive gambler in the entire country."

One way to forestall such possibilities would be to restrict two-way cable TV to anonymous response systems, in which there would be no way to identify the particular person responding to a call for an electronic vote or other cable query.

Other possible effects of EFT were outlined in a paper prepared for the conference by Robert H. Long and Wayne B. Lewin of the Bank Administration Institute. Assuming that a national EFT network will be in place by 1996, Messrs. Long and Lewin issued predictions for that year of obvious and more subtle secondary effects.

The advantages of having one's bank nearby would disappear with EFT, they said. Electronic transactions could be communicated from anywhere. The distinctions among the different types of financial institutions would also disappear in an EFT world. With banking possible from any location and all banks the same, banks would have to compete on the basis of services offered, rather than location or, for instance, per cent return on savings.

With so much computer power available and such large data bases on customers, banks will be able to provide much more sophisticated money management services than now. The financial institutions could train "family money managers" who could, at the customer's request, tailor-make individual budget programs from standardized program models.

Such concentrations of computer power and data on individuals will undoubtedly attract government regulation, they said, and this regulation will bring higher costs. Thus, it is unlikely that EFT systems will operate at much lower costs than today's systems. The fees, taxes, and additional operational procedures needed to meet the various privacy regulations, data base standards, operational reliability rules, and error correction standards will tend to counterbalance the inherent increased efficiency of the electronics.

EFT could make it possible to issue paychecks on a daily basis, and to pay bills on a daily basis, which would mean a more precise cash flow to the consumer. And it could be possible to control payments precisely for maximum benefits, for example, paying one's taxes precisely at 11:59 on April 15 of each year. Unfortunately, according to Long and Lewin, the government would probably already have gone to daily payment of taxes by then.

Other effects of EFT are not so obvious, said the two researchers. Because computers are more impersonal than human-centered systems, there might be an increase in "beat the system" types of crimes. The challenge of the game of ripping off the computer may be just too much.

"The person who today tries to beat the house in Las Vegas, develop a better system at the track, or spends hours looking for tax loopholes might find the challenge of 'beating' the electronic value transfer system too good to pass up. After all, *who* is hurt?" they asked.

Consumers may also feel they are losing the concept of value for work, in an EFT world. Today's paycheck is a concrete reward for work, but would an electronic record be just as rewarding?

"This could lead to a change in the symbols of value tied to the work situa-

tion," said Messrs. Long and Lewin. "Visible and tangible 'pay' such as office furnishings, badges, or uniforms may well become more important."

The ownership of EFT cards and other appurtenances of the system might also become social status symbols, they said, and could be used as reward or punishment to certain groups or individuals much like voting rights and attractive jobs have been used in the past.

The EFT system will also allow people to travel much more freely and securely without having to worry about access to funds. The difficulty of cashing checks or waiting until financial institutions are open will no longer be an encumbrance to the footloose person in the EFT society. People might also have more freedom to live where they choose; for instance, a stock investor need not live in New York to receive up-to-the-minute market reports.

Computerization will also hasten the consolidation of financial institutions under one regulatory umbrella, leading to more intense competition and a need for more careful government regulation. Such consolidation of funds in large EFT systems may also enable easier investment of large chunks of money, and computer systems will enable the seeker of capital to find out very quickly where capital is accumulating.

Finally, and perhaps most ominously, the concentration of data in EFT systems will tempt greater government control of the economy, for huge amounts of economic data will be readily available, tempting policymakers to act upon it. And the power of EFT records may also tempt government to gather information on the habits and finances of the public, perhaps endangering privacy.

Another conferee worried that the government may become the central EFT system and spawn inefficiences to rival those of the infamous U.S. postal system.

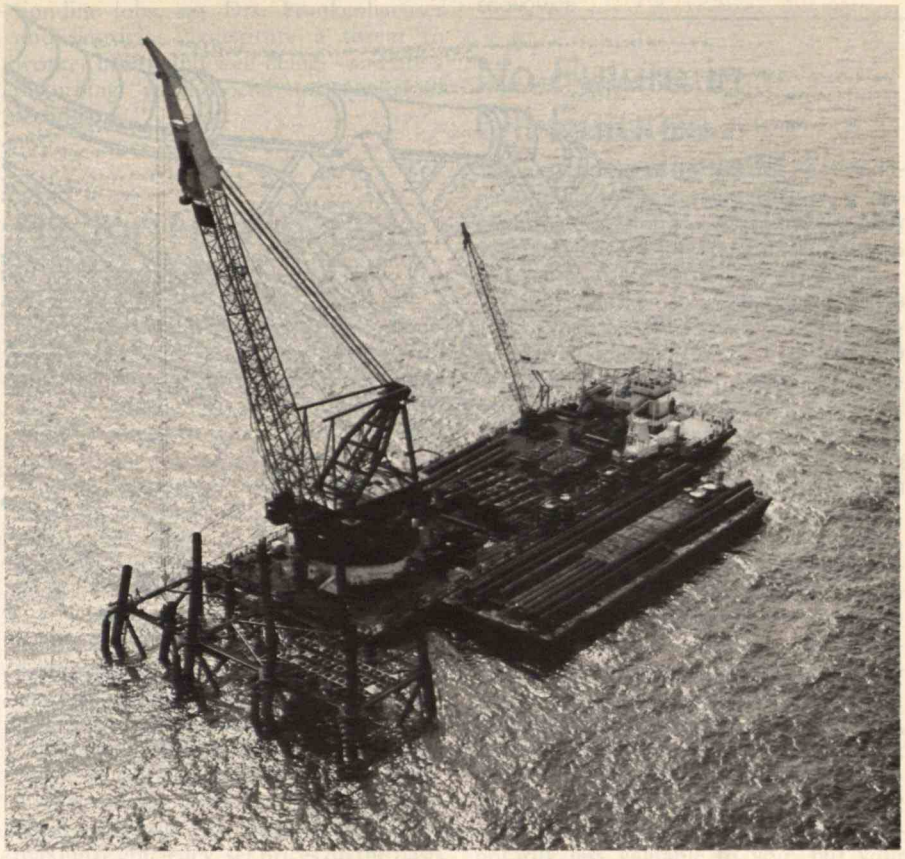
Clearly EFT is neither villain nor saint, concluded the conferees, but the potential for either is present in the system. It is up to Congress, business, and consumer groups to make early decisions on the best rules for the EFT game. — *D.M.*

JURISPRUDENCE AT SEA

Fishermen's Future at Georges Bank

Some estimates hold that there is a 5-percent chance of finding as much as 2.4 billion barrels of crude oil and 12.5 trillion cubic feet of gas under the smooth, sandy floor of Georges Bank, one of the world's prolific fishing grounds which escaped major damage from the *Argo Merchant's* 7.5 million-ton oil spill.

It's an interesting fantasy to speculate that fishermen, who have been on Georges Bank since before Europeans settled in North America, might sell drilling rights to johnny-come-lately oil men. But it won't work that way; when the oil rigs arrive, the fishermen's seniority will count not at all.



If oil and gas are found on the rich fishing grounds of Georges Bank off New England, what happens to the fishermen whose waters are preempted and whose drags are snarled in drillers' debris? There is no good answer to that question, say Thomas A. Grigalunas and Jon G. Sutinen of the University of Rhode Island; but they cite as possible prototype a fund-insurance plan developed in Scotland: oil men working in the North Sea pay into the fund on the basis of their offshore expenditures, and fishermen withdraw from it to offset their losses. (Photo: Brown and Root, Inc.)

But there will nevertheless be a "territorial issue," according to Thomas A. Grigalunas and Jon G. Sutinen of the University of Rhode Island's Department of Resource Economics at the "Oceans '76" conference in Washington last fall. It will arise through oil men preempting fishing ground for platforms and other constructed facilities and because of the carelessness of oil operators, whose debris will litter the ocean floor.

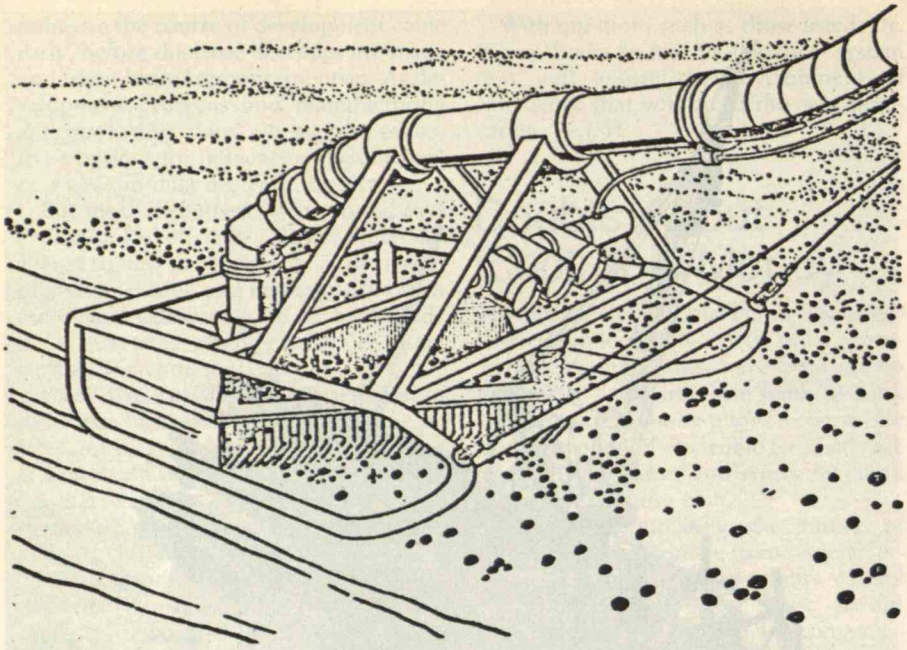
In theory, fishermen's views might be consulted when offshore facilities are to be sited, say Drs. Grigalunas and Sutinen. But as yet there are no accepted criteria for judging what will interfere with fishing and what won't, no mechanism for obtaining fishermen's consensus on the effects of oil company development plans. One alternative to avoid conflict is to withhold areas from oil development; but the economic cost — measured by the returns foregone — might be very high.

Metallic debris — tools, pieces of pipe, scrap, parts that slip away from workers — rains onto the bottom from drill rigs and supply ships. The result for fishermen is costly damage to nets and gear, and this is a major source of friction between oil men and fishermen.

A voluntary fund-insurance plan, now being tested among Scottish fishermen affected by North Sea oil operations, appeals to Drs. Grigalunas and Sutinen. Offshore operators contribute to the fund, and fishermen make claims against it to the value of their damaged and lost equipment.

However, fishermen in the North Sea have not, as yet, been able to collect from this plan for lost fishing time. Whether or not compensation could be paid to New England fishermen who may suffer down time as a result of oil-related accidents is not yet clear; it's an important issue, because several days' lost fishing time can impose substantial economic loss on a vessel owner and his crew.

Under the best of conditions the fund-insurance plan has three attributes which Drs. Grigalunas and Sutinen say are necessary for resolving tensions between the old men of the sea who gather fish and the newcomers who gather oil: it is efficient, equable, and pragmatic. — *J.M.*



A manganese nodule collector skims the ocean floor. In this, considered the most feasible design, a heavily-instrumented sled is dragged across the sea bottom, funneling the nodules into a suction tube. The sled features sonar, a depth finder, and a television camera monitored by operators on the surface. (Drawing: *Marine Technology Society Journal,* September, 1976, p. 11)

It's the Nickel in the Nodule

While the International Law of the Sea Conference fights its battles over who wins the ocean's resources *(see December, 1976, p. 15)*, a new economic study finds that manganese nodules on the ocean floor are definitely worth the squabble.

The study, performed by the Department of the Interior's Ocean Mining Administration, concludes that nickel extraction from the nodules will probably become profitable by the 1980s as land-based nickel deposits become more difficult to mine. Nickel will produce almost 70 per cent of gross revenues from deep-sea mining operations, while the two other principal metals in the ocean nodules — copper and cobalt — will yield far less. Although the lumps littering the ocean floor are dubbed manganese nodules, the actual extraction of manganese from them is doubtful; it will depend on the world manganese market in the 1980s.

Nickel appears to be the most economically viable product from the nodules, says the study, because new nickel mines on land will have to aim at extracting laterite nickel deposits, which are more difficult to mine than the sulfide deposits that until now have been the most important source of nickel.

The study theorizes that a mining operation with a 3 million-ton capacity of dry ore would require capital costs of from $3.89 to $5.92 per pound of nickel, compared with land-based laterite mine capital costs of $6.07 to $8.00. Operating costs for manganese nodule recovery would run from $1.01 to $1.39 per pound of nickel recovered, as opposed to $0.96 to $2.87 for a laterite nickel deposit.

The study only confirms the foresight of the four companies that have spent millions of dollars developing ocean mining techniques: Deep Sea Ventures, Inc., International Nickel-U.S., Kennecott Copper, and Lockheed Missiles and Space Corp. Each of these companies is allied with or partially owned by foreign mining interests from other developed countries, including Belgium, Japan, Canada, Germany, and the United Kingdom. — *D.M.*

HEALTH AND MEDICINE

Doctor Video

The lack of physicians in many communities has produced numerous proposals for using television to link doctors with their isolated patients. However, such visionaries might do well to examine the results of a research project in Miami, Fla., which concluded that paramedical nurse practitioners could perform just as well whether or not television allowed video consultation with qualified internists.

The project, conducted at the Dade County Prison Medical Services using the prisoners as a patient population, was described by Glen E. Hastings, M.D. of the University of Miami School of Medicine at the National Telecommunications Conference in Dallas this winter.

In 1974 nurse practitioners were introduced at the prison to give primary medical care to the approximately 1,700 inmates at the facility. In July, 1975, a two-way interactive television link was installed to connect the emergency room at the local hospital with the prison facility. During the telemedicine period, Dr. Hastings and his colleagues measured the proportion of patients visiting the practitioners, and the cost and quality of health care, and compared them with the pre-telemedicine period. They also administered questionnaires to determine the changes in attitudes of physicians, nurses and inmates about telemedicine. They also tested to determine the changes in medical knowledge of the nurse practitioners during the trial period.

The quality of care, as measured by physician review of cases and the number of medical errors, increased steadily throughout the program, and appeared to be unaffected by the advent of telemedicine, at least during the limited period of the study, said Dr. Hastings.

One big problem, he said, was that the nurse practitioners resisted using the telemedicine link. Dr. Hastings believed that the practitioners resisted telemedicine because when they felt doubtful about their ability to handle a case, they wanted to turn over the responsibility totally to the physician. A telemedicine consultation just didn't seem a complete transfer of responsibility to the practitioners, theorized the researchers.

On the other hand, the physicians in the study expressed markedly more confidence that telemedicine could be substituted for face-to-face management of patients.

The cost of providing care dropped rapidly when the nurse practitioner system was introduced, but increased when the telemedicine link was added. This does not necessarily mean that telemedicine is not cost effective, for in the Miami area the local hospital was quite close by for referrals. In a more dispersed setting, said the researchers, transportation costs might be much higher, making telemedicine a cheaper alternative. In their study, the need for a direct referral to a physician was obviated in 45 per cent of the episodes where a telemedicine consultation was needed. In a rural area this could mean quite large savings in patient or physician travel costs.

According to other researchers at the telecommunications conference, the Miami study was consistent with many others that demonstrated the effectiveness of distributed medical care. It should give pause, however, to those who would advocate telemedicine as a panacea. — *D.M.*

The Tyranny of Life Without Options

The amount of stress you experience seems to depend on your control of your situation — on how many options you have. The more your control, the less your stress.

Two kinds of evidence come from psychologists at the University of Stockholm.

Ulf Lundberg analyzed the stresses — measured by adrenaline levels in urine — on Stockholm-bound commuters from two stations on the Stockholm-Nynashamn railroad. Travelers who started the trip in an empty train at Nynashamn had their choice of seats and seat-mates; their adrenaline level was invariably lower upon arriving in Stockholm than that of those who boarded at a later station, when the train was nearly filled. Everyone's adrenaline levels rose during Sweden's 1974 oil crisis, when gasoline was rationed and trains crowded.

Dr. Lundberg has derived a formula: the stress on a commuter rises as the square of the number of passengers in the railroad car. A train traveler's stress rises, he says, because of the traveler's perception of being crowded. "Stress varies more with the social and ecological conditions of the trip than with its length or duration," he writes in the *Journal of Human Stress* (September, 1976).

Even stronger evidence linking stress to lack of options comes from Marianne Frankenhaeuser and Bertil Gardell, who report in the same journal on adrenaline levels in maintenance and production-line workers in a Swedish sawmill. Graders and sawyers on the production line are "tied to their machines." Their work is "characterized by severe physical strain, extreme repetitiveness, and restriction of social interaction and movement"; but their jobs require "unfailing attention." By contrast, repair and maintenance workers at the same mill — the "control" group in this experiment — have much freedom and "considerable influence over the pace and rhythm of their work," write Drs. Frankenhaeuser and Gardell.

The production workers' adrenaline levels increase sharply throughout the day after mid-morning, while those of the control group fall. There were also other signs of "stress and maladjustment" among production workers interviewed by Drs. Frankenhaeuser and Gardell. They blame "the monotonous, coervice, machine-paced nature of their work." The crucial stressor, they think, is "the demand on the worker to make skilled and economically important decisions in an extremely short time, at a pace completely set by the machine system."

Conventional wisdom holds that skilled decision-making insures pride and satisfaction in work. But when pace and method and no longer controlled by the worker, stress builds quickly. Production-line jobs, say Drs. Frankenhaeuser and Gardell, "constitute a threat to worker health and well-being," and are a disturbing "psychosocial consequence of technology." — *J.M.*

Rx for Health Care: Competition

Customers' whims may rule the supermarket and even the nation's largest industries, but not our health care system. The U.S. consumer is essentially impotent when it comes to what to buy and how much to pay for medical care.

These decisions are made almost exclusively by America's 320,000 doctors, and therein lies much of the "medical care problem," says Professor Jeffrey E. Harris of M.I.T.'s Department of Economics.

U.S. consumers spent $118 billion for health in 1975, more than they spent for defense or transportation — including the cost of new automobiles. Almost half of that was spent in and by hospitals.

Like most of us, Dr. Harris assumed — before he started working in medical economics — that hospitals, like other businesses, are run by their managers to maximize efficiency, set prices on the basis of services rendered, and respond to the pressures of the marketplace.

Not so, he finds. Price is calculated not in terms of the job done but in terms of services rendered. In other words, your hospital bill is not written as the cost of "treating a heart attack"; instead, you are billed for room and board, tests, and nursing services your doctor chooses to ask for in your behalf, says Dr. Harris.

Doctors make most of the management decisions that have significant impact on hospital costs — what equipment to buy, what facilities to build, and what services to offer. There's a tendency to grow for the sake of growing: "If you can't be on the staff at Massachusetts General Hospital, the next best thing is to turn your hospital into another Mass. General," says Professor Harvey Sapolsky of the M.I.T. Department of Political Science, a colleague of Dr. Harris.

In these and other ways, the system insulates itself from the will of the patient whom it serves. Indeed, says Dr. Harris, "there is something repugnant about money as a factor in health care" — quite in contrast to other forms of consumer-supplier relations in the U.S.

To make health care seem less monolithic and perhaps even gain a measure of competition, Professor Sapolsky suggests incorporating separate agencies for different services — ambulatory care, intensive care, preventive care. Patients and their doctors together could choose among agencies, weighing the different benefits assured by each against its costs. — *J.M.*

No Future in Oil Futures

The future price of oil will not be very different from today in real terms — i.e. discounting inflation — even by the year 2000, say two M.I.T. economists, Jacques C. Cremer and Martin L. Weitzman.

The dramatic rise in world oil prices during the past four years was "a once-and-for-all phenomenon . . . unlikely to be repeated again," they say in a 1976 report of the M.I.T. Energy Laboratory.

If you find this answer surprising, think of an O.P.E.C. minister whose job it is to help manage the pricing and production of his region's monopoly on oil.

The oil under your desert is plentiful, and it costs far less than today's price — $12 per barrel — to produce. You know that the price must go up for eventually your competition — the U.S., for example, or the nations bordering the North Sea — will produce less and need more.

If you set your present price too high, you will discourage world demand for your oil and — at the same time — encourage marginal production among your competitors. Your monopoly will be temporarily less valuable to you; but your competitors' finite resources will be depleted faster, and eventually your monopoly will be even stronger.

On the other hand, the money you make on oil you sell now is more valuable than the money you will make later: today's profits give you capital to invest for assured future income, while tomorrow's profits will be in oil which has earned no income at all. (If the real interest you can earn on capital goes down — say, from 5 to 3 per cent — then present profits become less valuable, future profits more appealing, and your strategy may change.)

To help them balance all these issues and paradoxes against each other, Mr. Cremer and Professor Weitzman put them together in a computer-based model which predicts the O.P.E.C. nations' interests and world oil prices. Their "most likely" scenario proposes a real price increase of only $5 per barrel — in 1975 dollars — during the next 20 years. Even substantial changes in assumptions about costs, reserves, demand, competitors' production, and alternative investments have negligible effect on this result.

There are reservations, of course; Mr. Cremer and Professor Weitzman admit that their model is "very crude." It ignores price uncertainty; the implication of "rational behavior may not be appropriate to the present problem"; and its assumption that the O.P.E.C. countries will behave as a "single monopolist" may be "very unrealistic." But they argue that these are unlikely to jeopardize the general validity of their result, which comes from a model they believe is "basically valid." — *J.M.*

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The recycling of materials has traditionally been governed by the incentives of the marketplace. Now there are also new driving forces: waste disposal, environmental integrity, and long-term conservation.

Recycling in the Materials System

Shortages and surplusses follow each other in unending succession in the U.S. paper market, and the market for recycled paperstock is similarly volatile. This Georgia-Pacific mill, which can convert 33,000 tons per year of scrap paper into reusable fibers, is one of the country's largest. Significant savings of both materials and energy are claimed.

Recycling can yield five kinds of benefits: it contributes to the supply of materials; it reduces the volume of waste; and it usually results in energy, environmental, and process savings. The contributions to materials supplies and waste disposal are inherent in recycling; always accrue, at least in principle; and are the main driving forces of recycling. The energy, environmental, and process savings are contingent on the efficiency of the recycling operation.

How much recycling contributes to materials supplies and waste disposal depends on the material involved. As an extreme example, the recycling of precious metals used in small amounts — highly dispersed — in such applications as communications equipment and photographic materials will be increasingly necessary as a means of conserving supplies, especially of silver, but it makes a negligible contribution to waste disposal. At the opposite extreme, the recycling of the glass fraction in municipal solid waste appears to be viable primarily as a means of reducing waste disposal problems.

Energy, environmental, and process savings from recycling are possible because recycled (secondary) materials, such as scrap metals and waste paper ("paperstock"), are closer in composition to the final product than primary raw materials, such as ores and wood pulp. If there are to be savings from the collection and use of secondary materials, the expenditure of energy, the pollution abatement costs, and the costs of collecting and processing those materials must be less than the corresponding inputs for primary production. This requirement is one reason why total recycling will not be economically attractive.

The amounts of energy saved by the production of materials from secondary rather than primary sources are not well known. Clearly they involve the thermodynamic energy requirements of the processing reactions; for secondary processing of several metals, these are on the order of 5 per cent of those for primary production. These energy requirements, however, were calculated for idealized processes and do not represent the energies expended in actual operations. In estimating the latter, the energies expended in such major operations as collecting, transporting, and preparing scrap metals and other secondary materials must be taken into account, and against these must be set the energies required for primary production, as in the mining, milling, and processing of ores.

It is possible to assess the relative pollution effects of primary and secondary production. For example, the use of ferrous scrap in the production of steel permits bypas-

sing the iron blast furnace, and this eliminates the pollution associated with this process and with the production of coke. Similarly, the recycling of copper scrap usually causes much less pollution than the extraction of copper from low-grade sulfide ores. Secondary production processes, however, often are significant pollution sources of their own: for example, processes for the recovery of lead from batteries and the recycling of newspapers can cause extensive pollution, and abatement measures add to the costs of secondary production.

Secondary production usually requires less chemical or metallurgical processing than primary production. Entire sections of a process flowsheet may be bypassed, as already illustrated by the case of ferrous scrap and the blast furnace. The secondary production of many materials may be carried out in plants which are simpler and require less capital investment than primary production plants. This leads to another advantage of secondary production: it is often more flexible than, for example, production based on mining operations; in particular, new secondary plants can be constructed in much less time than new mining and smelting capacity, and they can be located according to market considerations with less regard to resource availability. Operating costs for secondary production are lower in a majority of cases, although some steps in secondary production still tend to be labor-intensive. In favorable cases, the costs of secondary production may be only 25 to 35 per cent of those of primary production.

The recycling of materials, especially metals, is as old as their use. Many metals and some other materials at present are recycled by established secondary and, in some instances, primary producers, and these industries have achieved significant technical advances in the handling of secondary materials; for example, the introduction of capital equipment has reduced the labor-intensive nature of secondary processing. The technology of secondary materials is by no means primitive, nor is it fully mature; technical innovations can be expected as these industries continue to develop. (In contrast to the established secondary industries, resource recovery from municipal solid waste presents a completely new challenge, and it poses great technical and institutional problems, some of which are reviewed below.)

Secondary Materials: Home, Industrial, and Old Scrap

Secondary materials are generated at all stages of materials processing and utilization, and special terms are customarily used to describe these materials with respect to their origins. "Home scrap" is the residual material from primary production, which can be returned directly to the production process. For example, part of the steel cast into an ingot mold — exceeding, in fact, 10 per cent of the steel originally committed to the mold — cannot be used in the ensuing processes; it is removed and charged again to the steelmaking furnace. Continuous casting, which has been replacing some ingot casting, produces less scrap and thus tends to reduce the amount of available home scrap in the industry. In general, it is characteristic of the dynamic nature of secondary materials sup-

ply and demand that a technological change unrelated to the secondary materials industry may impose change on that industry. This dynamic character of scrap supply and demand is frequently ignored in discussions of raw materials policies.

"Prompt industrial scrap" or "new scrap" is that generated in manufacturing processes — for example, the clippings from a stamping operation or the chips of metal from a machine shop.

Both these forms of secondary materials — "home scrap" and "new scrap" — are established parts of the flows of materials through industry, though they are not covered by "recycling" as most of us would define that term. We are thinking of "old scrap" — that generated from a product which has completed its useful life, a "scrapped" automobile, for example. A generic diagram of the flow of materials (*see page 26*) indicates how these major types of recycling relate to primary materials and various processing and manufacturing operations.

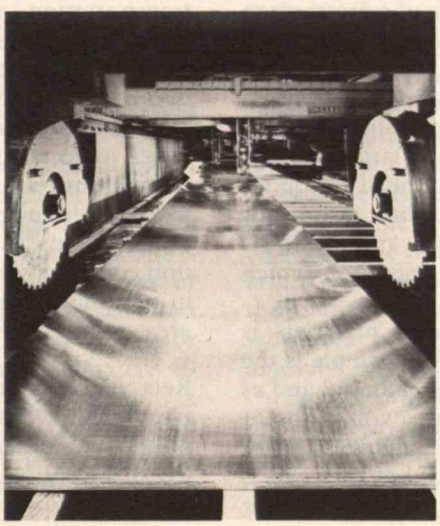
The recycling of home scrap is an important feature of the primary production of some materials — in particular, of steel; similar in-house recycling is common in the chemical industries. These recycling practices improve yields, increase processing efficiency, lower costs, and avoid disposal problems.

Like home scrap, prompt industrial scrap, generated by manufacturing industries, is recovered almost automatically, at least by well-managed firms, as a matter of good industrial housekeeping and resource conservation inspired by economics. There may be some opportunities for increased recoveries by smaller firms; newer metals such as titanium also present opportunities for enhanced recovery. But the basic issue for production managers is to keep the amounts of home scrap and prompt industrial scrap as low as possible in order to save the energy, labor, and processing required to produce the material and then to recover it as scrap and to avoid attendant material losses. Indeed, reducing the amount of prompt industrial scrap is a current objective of much research and development aimed at improving manufacturing operations.

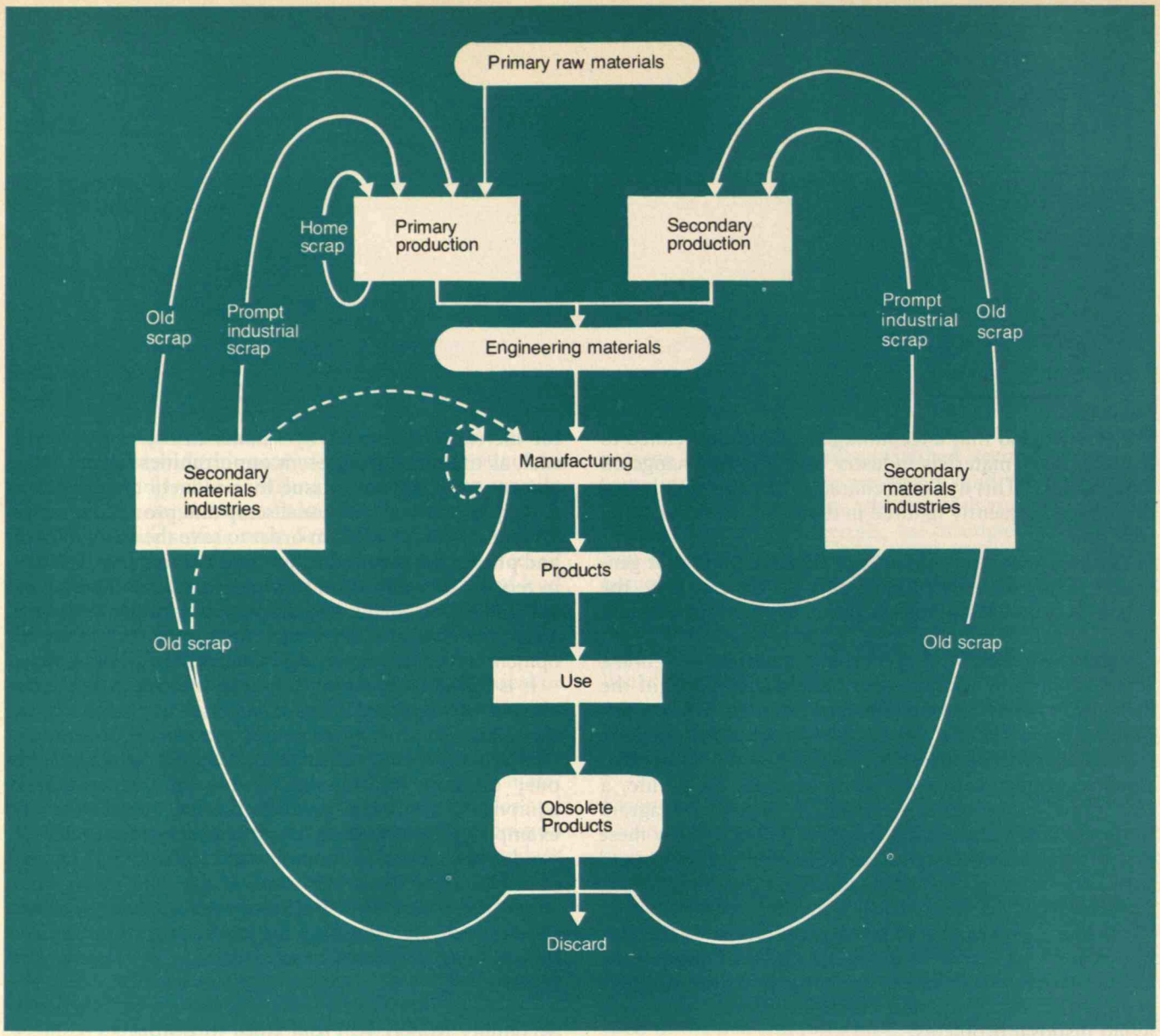
It is in the recovery of old scrap that we now see significant new opportunities for materials conservation and waste disposal through increased recycling. Old scrap occurs in many forms, of which municipal solid waste is but one; obsolete automobiles and other transportation equipment, industrial machinery, and packaging are examples. The degree to which old scrap is recycled depends on technical, economic, and institutional factors; effective materials conservation in the long run is predicated upon successful business conduct, which in turn depends on understanding the market for old scrap and the technical problems in its collection, processing, and reuse.

Secondary Materials: From Ships to Bottles

Some segments of the secondary materials industries have a long history in the U.S. Shipbreaking has been a traditional source of ferrous and nonferrous scrap. Auto shredders are a recent development which has contributed to solving the junk auto problem while making obso-



Turning bauxite into aluminum is energy-intensive — and therein lies a principal incentive for aluminum recycle: the use of aluminum scrap saves much of the energy needed to make primary aluminum. These pictures suggest the sequence of collecting, shredding, smelting, casting into ingots, and rolling into sheet. They do not show one step in the recovery of aluminum from municipal solid waste: the extraction of aluminum from the solid waste stream. (Photos: Reynolds Metals Co.)



This diagram of the materials system shows how recycling provides loops from all levels of materials processing and use back to the inputs to production through the primary or secondary materials industries. "Old scrap" from discarded products joins "prompt industrial scrap" from manufacturing industries in flowing either to secondary materials producers or to primary producers.

lete automobiles the largest single source of ferrous scrap and also a major source of several nonferrous scrap metals.

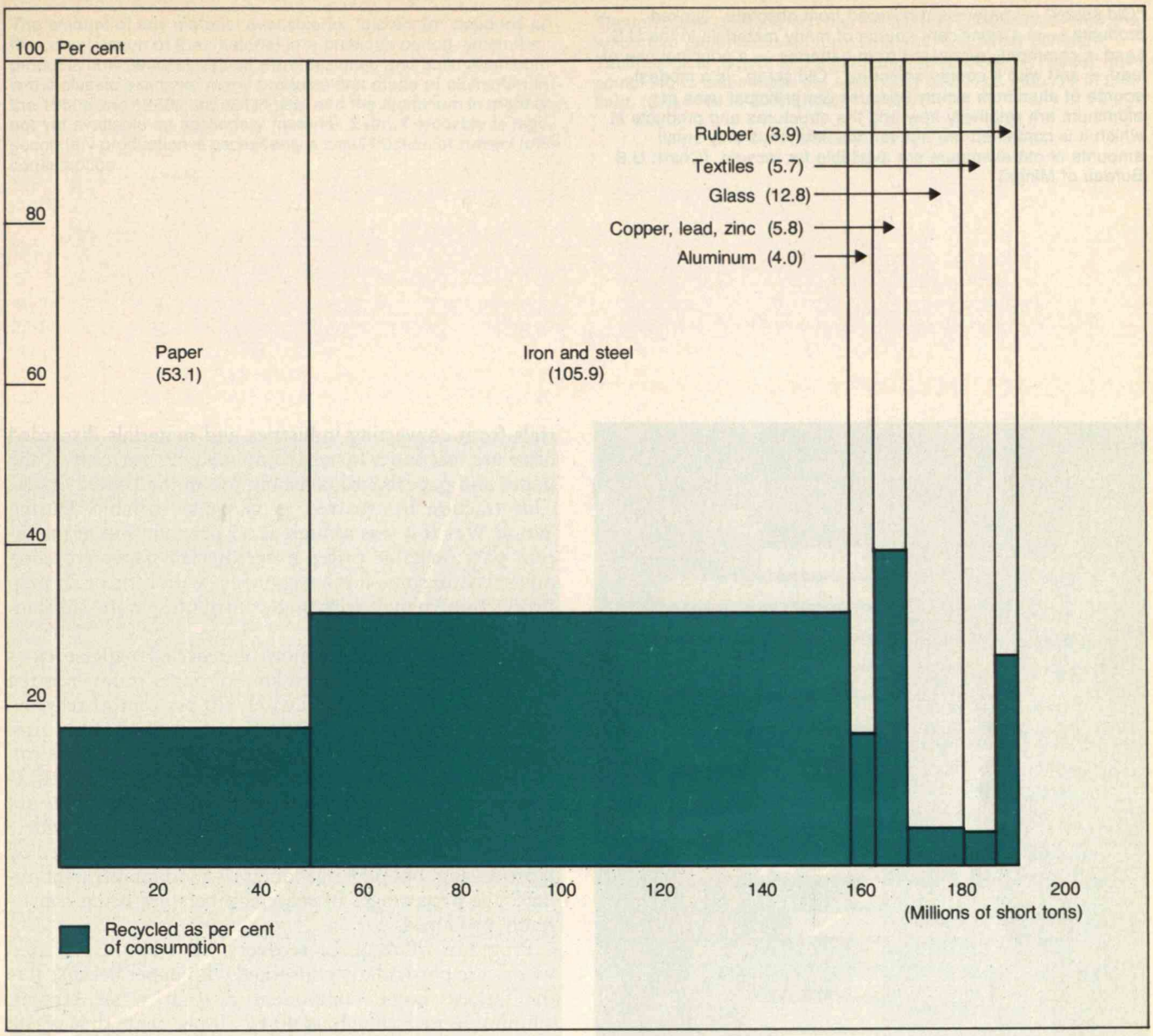
Appreciable amounts of some secondary materials of good quality are supplied directly to manufacturing industries; in particular, brass mills consume large amounts of brass scrap. Ferrous scrap directly supplied to foundries accounts for a very large fraction of their ferrous input. The recycling of aluminum cans by primary producers has evolved into a closed-loop operation which produces new can stock.

The utilization of wastes and recycled materials is common in the construction industry. An example is the use of blast-furnace slag as road-building material and as railroad ballast. A current development involves the *in situ* recycling of old asphalt-concrete highway pavements; new binding materials are added, but the road is resurfaced mostly with material that is already in place; transportation, waste disposal and materials requirements are thus reduced. Much current research is also directed at incorporating glass from municipal solid waste into construction materials.

Reuse represents an alternative mode of recycling in which objects are reconditioned and returned to their original functions. The salvage of parts by the automobile wrecking industry is the most important example. Large organizations such as communications and transportation companies and the military services also are engaged in programs of reclamation and reuse. In the consumer area, returnable bottles fall into the same category.

Recycling as a Source of Industrial Strength

How shall we assess the viability of recycling and its present and potential contributions to industrial prosperity? Conventional economics provides one such assessment. Market forces drive the recycling of materials, and



Nearly 40 per cent of the copper and nearly one-third of all the iron and steel consumed in the U.S. in 1967 was contributed by recycling new and old scrap. The small percentage of glass recycled is the result of two factors: the relative difficulty of processing waste glass and the abundance and low cost of the raw materials from which it is made. The numbers in parentheses are the amounts (in short tons) of total U.S. consumption of the materials indicated. (Chart: National Commission on Materials Policy, 1973)

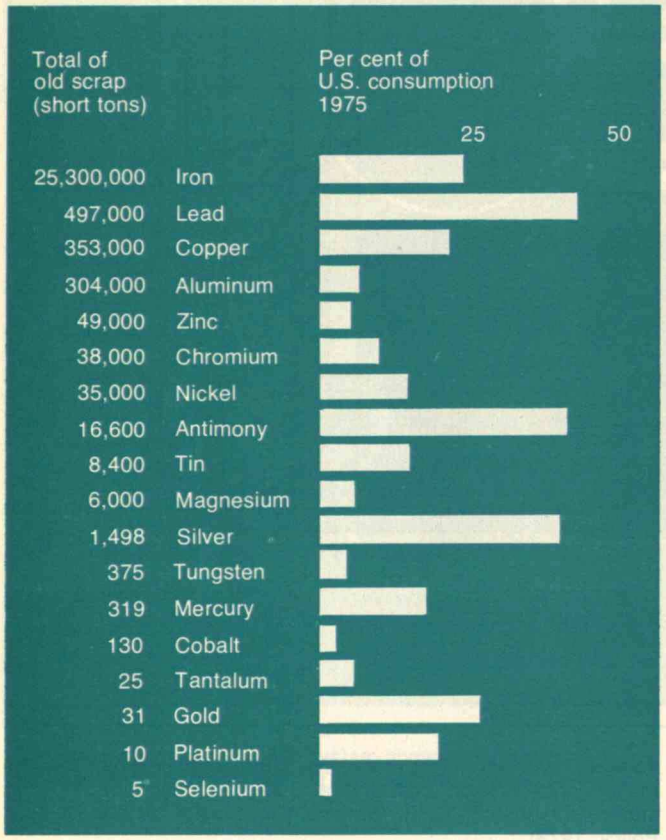
the profit motive is the primary incentive of the secondary materials industries, which are engaged in collecting and sorting secondary materials and preparing them for further processing — and in some cases in the processing itself.

The contributions recycling makes can be calculated in terms of the ratios of recycled materials to total current consumption. On a world-wide basis, such assessments tend to be reassuring for the consuming countries; this is because secondary materials are alternative sources of supply which substitute for primary raw materials and reduce the threat of cartels. For example, scrap is a major factor in the world supply of copper; approximately 40 per cent of current consumption in the western world is provided by new and old scrap. A cartel of countries producing copper ore and seeking to raise its price confronts this substantial competition. The reasons for the high recycling rate of copper are technical and economic; they include the indestructibility of copper, its predominant use in durable goods, and its relatively high price.

Secondary materials can also be viewed from the standpoint of individual countries. From this point of view, the contributions recycling can make depend in part on the length of time a material has been in use. Supplies of new metals such as magnesium and titanium are seldom available from secondary sources. With respect to recycling, the industrialized countries, which are still the largest consumers of materials, have special advantages: they have accumulated large reservoirs of most materials which can be recycled, and they also generate the largest amounts of prompt industrial scrap.

Ferrous scrap has an important role in U.S. steelmaking, and recycling makes an even larger contribution in the case of the traditional nonferrous metals, in particular copper and lead. The high recovery rate of lead in the United States is especially remarkable since several

"Old scrap" — materials recovered from obsolete, "junked" products — is a significant source of many materials in the U.S. Lead is commonly recovered from batteries — a principal use of lead — and with it comes antimony. "Old scrap" is a modest source of aluminum simply because our principal uses of aluminum are relatively new and the structures and products in which it is contained are not yet obsolete; thus only small amounts of old aluminum are available for recycle. (Chart: U.S. Bureau of Mines)



hundred thousand tons of lead are devoted annually to dissipative uses, the largest being gasoline additives. The United States outperforms all other countries in the recovery of copper.

Approximately half of U.S. antimony production is based on recycled material due to the extensive recovery of antimonial lead, especially from batteries; this is an example of "co-recovery" — the antimony is recovered in the course of recovering lead and is a useful byproduct.

Recycled aluminum contributes about 20 per cent and rubber about 25 per cent to current U.S. consumption. But only about 6 per cent of current aluminum production is based on *old* aluminum scrap — a fact which is explained by the rapid growth in the use of aluminum during the last quarter-century.

The contributions of secondary glass and textiles are very small, due to both economic and technical factors.

Recycled paperstock, including both secondary materials from converting industries and materials discarded after use, accounts for approximately 20 per cent of the paper and paperboard consumption in the United States. This fraction has proved to be quite variable. During World War II it was as high as 35 per cent, but in the recent past unstable prices have affected paper recycling adversely. In some foreign countries with little or no pulp production, paper recycling contributes more substantially to paper supplies.

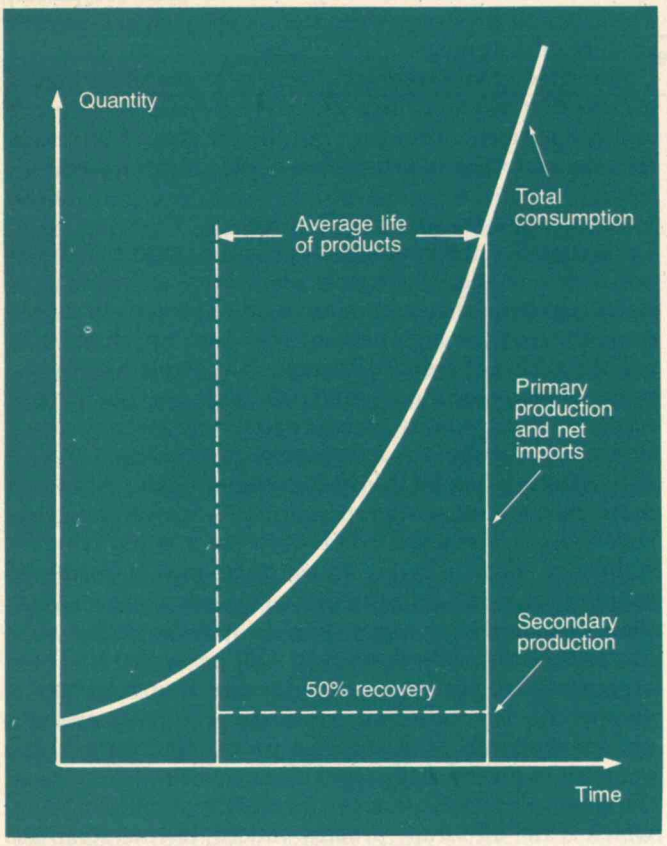
A relatively small fraction of recycled paperstock is converted back to the same kind of paper product as the starting material. Approximately 70 per cent of recycled paper is processed into paperboard. Among other uses are paper-based construction materials. Newspapers can be recycled separately in a closed loop and returned as newsprint. Most other products from recycled paper are of a lower grade than the starting material. It is widely assumed that the cellulose fibers in paper are degraded by reprocessing, but paper products of good quality containing large percentages of recycled fibers are being consistently produced.

Programs of resource recovery from municipal solid wastes are particularly concerned with paper because it is the largest single component of that waste stream, amounting to as much as 40 to 50 per cent; thus waste disposal — not conservation or energy saving, though these are additional benefits — is the principal driving force for the recycling of most post-consumer paper. Segregation at the source and separate collection would facilitate recovery, but there is little evidence that most urban residents can be persuaded under present conditions to separate paper, glass, and metal in their trash. Current planning in this country for the recovery of paper from municipal solid waste concentrates on its value as a fuel, in which some contamination can be tolerated. It is interesting to note that paper is the only major recovered material which is derived from a renewable resource, and that it will probably be recovered from municipal waste, if at all, mostly as a fuel.

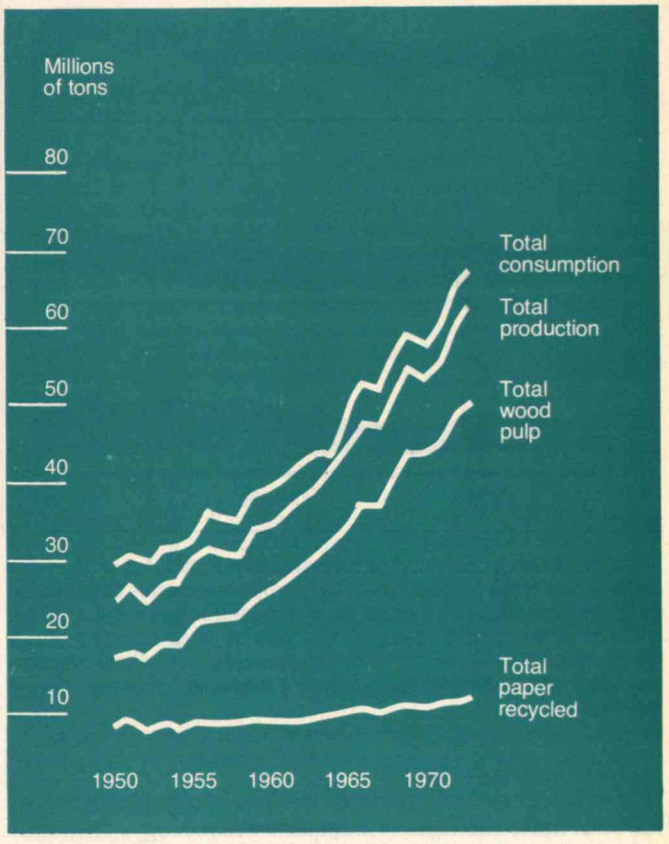
In addition to the difficulty of segregating and separately collecting waste paper, there are both operational and technological problems in the recycling of paper. Unlike scrap metals, paperstock cannot be stored conveniently and for long periods. Printing ink must be removed from paperstock before recycling if the new product is to be used for printing; newly developed inks, coatings, and adhesives used for binding complicate the necessary processing.

The recycling of post-user glass ("cullet") is inhibited

The amount of any material available as "old scrap" depends on the consumption of that material in a previous period, when the products now being scrapped were designed and built. Aluminum is the classic example: many products first made of aluminum in the 1950s and 1960s are still in use, and the aluminum in them is not yet available as secondary material. Even if recovery is high, secondary production is necessarily a small fraction of current total consumption.



Though paper consumption has increased steadily since 1950, the amount of paper recycled has remained essentially constant. Technological factors and institutional and economic issues have combined to discourage the secondary materials industry in this field. (Chart: E. L. Graminski)



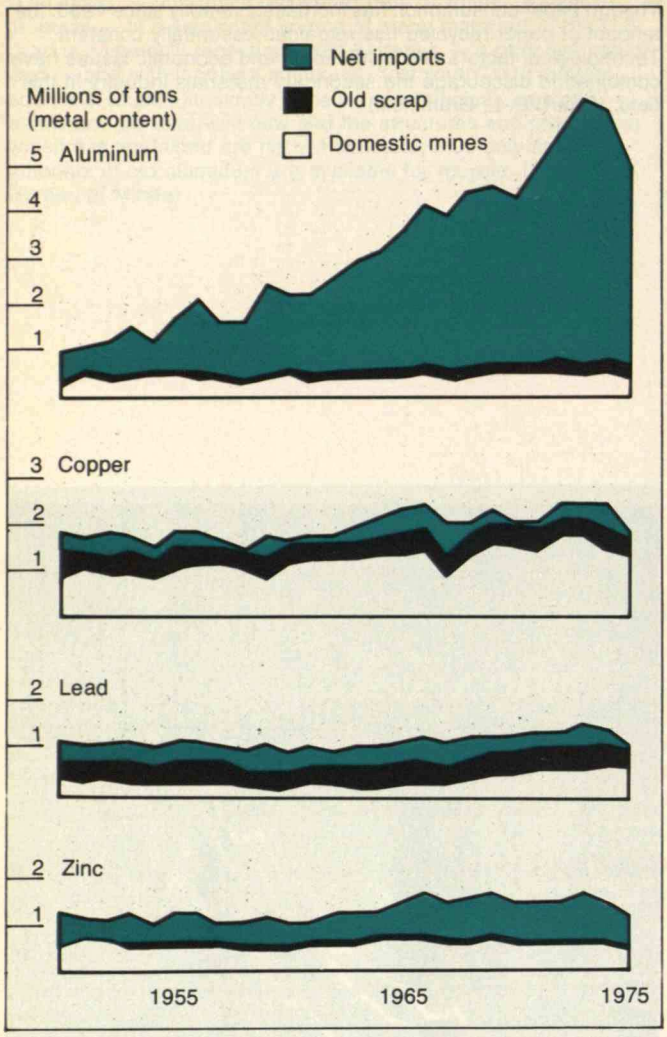
by both economic and technical factors. Because of the low value and wide distribution of the raw materials for producing glass, the economic incentive for recycling is limited; some fuel savings, however, result from the use of cullet in glassmaking. Contamination of cullet presents the most serious technical problem in the recycling of glass, especially in the production of containers. Cullet must be sorted by color for any but the least demanding applications, and automated sorting techniques have been developed.

There is research on new applications for recycled glass in the construction industry, for example for producing building blocks or bricks. The chief driving force for the recycling of glass, like paper, is waste disposal.

Plastics are generally recycled as prompt industrial scrap within the plastics industry. Thermoplastic materials which have been discarded after use may in principle be recycled, but their reuse in practice is complicated by the large variety of polymeric materials used and by the difficulty of separating them from other materials in municipal solid waste. In currently planned projects for dealing with municipal waste, plastics are commonly recovered as part of the fuel fraction.

Plastic parts in junk automobiles will probably be recovered by new techniques related to auto shredding. Plastics from furniture, appliance housings, and construction components, which rarely enter the municipal solid waste stream, will perhaps also be recovered in the future.

The recycling of rubber is limited largely by technical difficulties associated with reclaiming vulcanized rubber. Tires have also become increasingly complex so that the rubber must be separated from other materials, notably fibers and steel wire. However, recycled rubber supplies about 25 per cent of U.S. consumption, and some use of scrap tires for their heating value as fuel has been reported. The recapping of tires is an important example of reuse.



Institutional and economic factors are responsible for wide differences in the proportions of our nonferrous metals obtained by recycling. Aluminum is a relatively new material; by contrast, in the case of copper and lead recycling draws on large supplies of obsolete goods. Old scrap of zinc makes only a small contribution because zinc and its alloys are widely dispersed in many applications.

Technological Problems

Three categories of problems tend to inhibit the recycling of materials: the lack of adequate technology, economic and institutional issues, and problems of information and interpretation. Many of the technical processing problems have a common origin in contamination which typically characterizes secondary materials. Tin and copper, for example, are often present in ferrous scrap, and their concentration must be reduced before the scrap is used in steelmaking. This is a difficult technological problem involving both mechanical and metallurgical processing, and solutions are only now being found. Detinning of post-user steel cans will make the ferrous product a desirable raw material for steelmaking. Improved procedures in automobile shredding will reduce the copper content of ferrous scrap. Other impurities, including alloy elements which if added deliberately are desirable in alloy steels, must be identified by chemical analysis and eliminated by sorting of steel scrap.

Aluminum scrap will present special problems and opportunities in the future because it will become available in increasing amounts. This is likely to saturate the market for secondary aluminum alloys, which at present are used mainly as diecasting and foundry alloys. A loosening of unnecessarily strict specifications on some other aluminum alloys will be helpful. The best solution would be technology capable of eliminating from aluminum scrap impurities and unwanted alloy elements; such refining technology does not now exist (except for the removal of magnesium) and is not easy to imagine in terms of traditional metallurgy because aluminum itself is chemically so active.

Composite materials present the greatest technical difficulties for recycling, since many of them cannot be decomposed into their component parts, which would be necessary for recovery. An example is plated steel, where a corrosion-resistant metal serves as protection. Because it is difficult to recover the thin plating layer, it has been proposed in some instances to make the entire component of a corrosion-resistant alloy which is then recyclable. This example illustrates the systems approach to materials conservation strategies.

A review of the technical barriers to recycling makes it clear that most of them are likely to yield to research and development. They are basically the kind of problems that the materials industries have solved in the past.

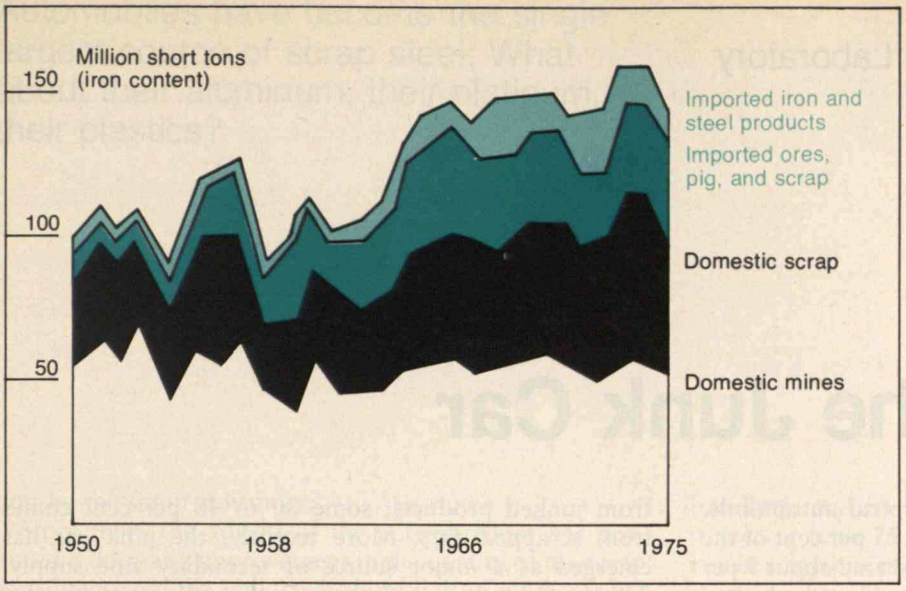
Economic and Institutional Problems

Spokesmen for the established secondary industries point out that secondary materials often serve in a substitutional capacity; that is, they are used to fill gaps in supply during periods of high demand, but they are the first to feel the effects of reduced demand. This explains why the prices of many secondary materials are more volatile than those of their primary counterparts, and it represents a substantial deterrent to investment in recycling.

In addition, the established secondary industries — in particular, the ferrous scrap industry — view resource recovery from municipal solid waste as a potentially destabilizing factor. It is argued that greatly increased supplies could result from processing such waste and that these new sources of supply should not be developed without assurance that new markets will be available. These arguments are not without some merit, but a less static view of the demand-supply relations of primary and secondary materials is needed. Consider, for example, the prospective growth in demand for ferrous scrap because of the continuing expansion of electric-furnace steelmaking, which is an "all-scrap" process. Indeed, ferrous scrap has frequently been in short supply, and under such circumstances scrap has become a political issue when restrictions were imposed on its export. (The same issue arose during the period of copper shortages in 1973 and 1974, when an embargo on secondary copper was considered.)

There are artificial economic barriers and disincentives to recycling. It has been claimed that freight rates and taxation discriminate in favor of primary production, but comparisons are difficult; for example, comparing respective freight rates is complicated by the fact that the processing of primary materials may require large amounts of indirect materials (such as fuels) which must also be transported. The depletion allowance available to primary but not to secondary producers has been cited as unequal treatment of primary and secondary materials. It is clear that policies adopted in the 19th century to promote mineral development in the United States should be reviewed for their continuing need and appropriateness.

Recycling of materials may appear to be particularly attractive for developing countries because it is less



"Old scrap" is a significant and growing source of raw material for U.S. iron and steel making; indeed, if "old," "prompt industrial," and "home" scrap are taken together, recycling currently provides nearly half of the iron used in the nation. (Chart: U.S. Bureau of Mines)

capital-intensive and more labor-intensive than primary production. In view of this, the United Nations Industrial Development Organization has made efforts to promote recycling of nonferrous metals in less developed countries. But recycling old scrap depends on the existence of a pool of obsolete goods from which the scrap will come, and recycling prompt industrial scrap depends on industries which generate large amounts of such material. These conditions are not generally met in developing countries, and for them recycling therefore holds only limited promise at present. Paper, rubber, and textiles may be the most promising secondary materials in developing countries.

Problems of Interpretation

There is extensive statistical information concerning most recycled materials in western countries and Japan, but a few basic problems make policy studies difficult. We lack complete data on the amounts and costs, for example, of the prompt industrial scrap which is recycled directly back into manufacturing industries. Even more important, we also lack reliable information on the magnitude of the pools of the major secondary materials — particularly the pool of ferrous scrap, which has been said to be as much as 1 billion tons or even more in this country, so that we cannot determine the physically possible maximum production from secondary sources.

Information on the costs and efficiencies of secondary industries is proprietary — and therefore necessarily limited. The costs of greatly increased recycling are not known. The question of the optimum amount of recycling has different answers for different materials at different times, depending on the labor, capital, indirect materials, and energy required for recycling. The economic optimum for recycling is also affected by other materials conservation strategies, such as the increased durability of products or substitutions in the materials from which they are made (light-weight plastics for steel in automobiles, for example). The effects of such changes are not yet well understood.

All these uncertainties support the view that recycling is one element in a complex materials supply system, and they point to the importance of a systems approach to materials conservation.

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Recycling the Junk Car

Consider the materials content of a typical automobile. Steel and iron castings constitute about 75 per cent of the vehicle's weight; aluminum, copper, and zinc about 5 per cent each; glass and rubber about 2.5 per cent each; and plastics have now become about 4 per cent. Extrapolate these proportions over a production rate ranging between eight and 12 million vehicles per year, and it is easy to see why the U.S. automotive industry is such a major consumer of mineral and materials resources. In recent years the U.S. industry has consumed 20 per cent of the steel and ferrous castings, 68 per cent of the lead, 33 per cent of the zinc, 8 to 9 per cent of the copper and aluminum, 65 per cent of the rubber, and 5 per cent of the plastics used in the United States. If these huge volumes of materials were not recoverable from junked vehicles, the modern automobile well might be charged as a main agent of our mineral and metal resource depletion.

But in point of fact, 6 to 8 million cars are scrapped each year, and about four-fifths of these are being recycled for their metal and material content. Indeed, it has been estimated that more junk cars have been recycled in the past three years than were retired from service during that time. This has resulted in a reduction in the national inventory of junk cars, and the junk car has become the largest single source of post-consumer steel scrap — scrap from junked products; some 30 to 40 per cent comes from scrapped cars. More recently, the junk car has emerged as a major source of secondary zinc supply. Clearly the junked car is the most recyclable and recycled of post-consumer products. It is the intent of this paper to demonstrate that the recycling of junk vehicles may represent a model of what can be done when favorable economics, industrial technology, available markets, and national and social needs co-exist.

The Processing of Junk Vehicles

The primary economic incentive for recycling a junk car has been the recovery of iron and steel, which make up the bulk of its weight. Their value depends upon the cost of collecting and bringing scrapped vehicles to processing centers, the cost of scrap transportation, the quality and ease of handling of the scrap, and the fluctuating prices of iron and steel scrap.

Until about the mid-sixties, most junk cars were processed by a variety of operations that included hand dismantling and sorting, incineration, shearing, and baling. The quality and costs of scrap processed by these methods reflected a volatility in demand: when total demand for steel scrap was low, scrap from automobiles was among the first varieties eliminated from considera-

Automobiles have become the single largest source of scrap steel. What about their aluminum, their platinum, their plastics?

tion by the scrap consumer.

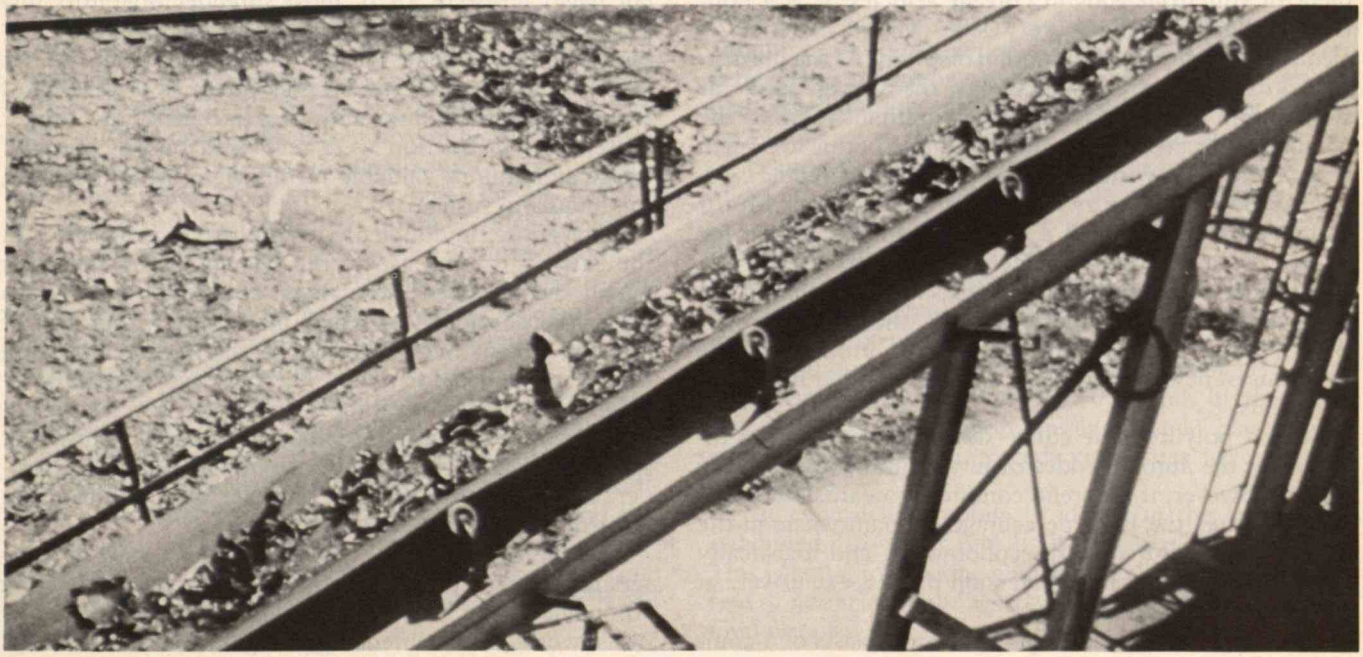
Since then, the advent of the auto-shredder has produced a dramatic improvement in the quality of the scrap generated from the junk car. About half of all discarded vehicles in the U.S. are now processed by these giant machines; many of them can handle up to 300,000 units per year. The auto-shredder also has facilitated the economic separation and recovery of the non-metallic material, thus improving considerably the total profitability of the process.

The auto-shredder operates as follows: Entire automobiles, from which tires, fuel tanks, batteries, and radiators usually have been removed, are fed into a so-called hammer mill. The mill literally shreds the automobile into fist-sized fragments. As shown schematically on page 34, a series of air systems and magnetic separators then produces three scrap fractions: a magnetic (ferrous) fraction; an "air fraction" containing very low-density non-metallic debris; and a non-ferrous, non-magnetic fraction.

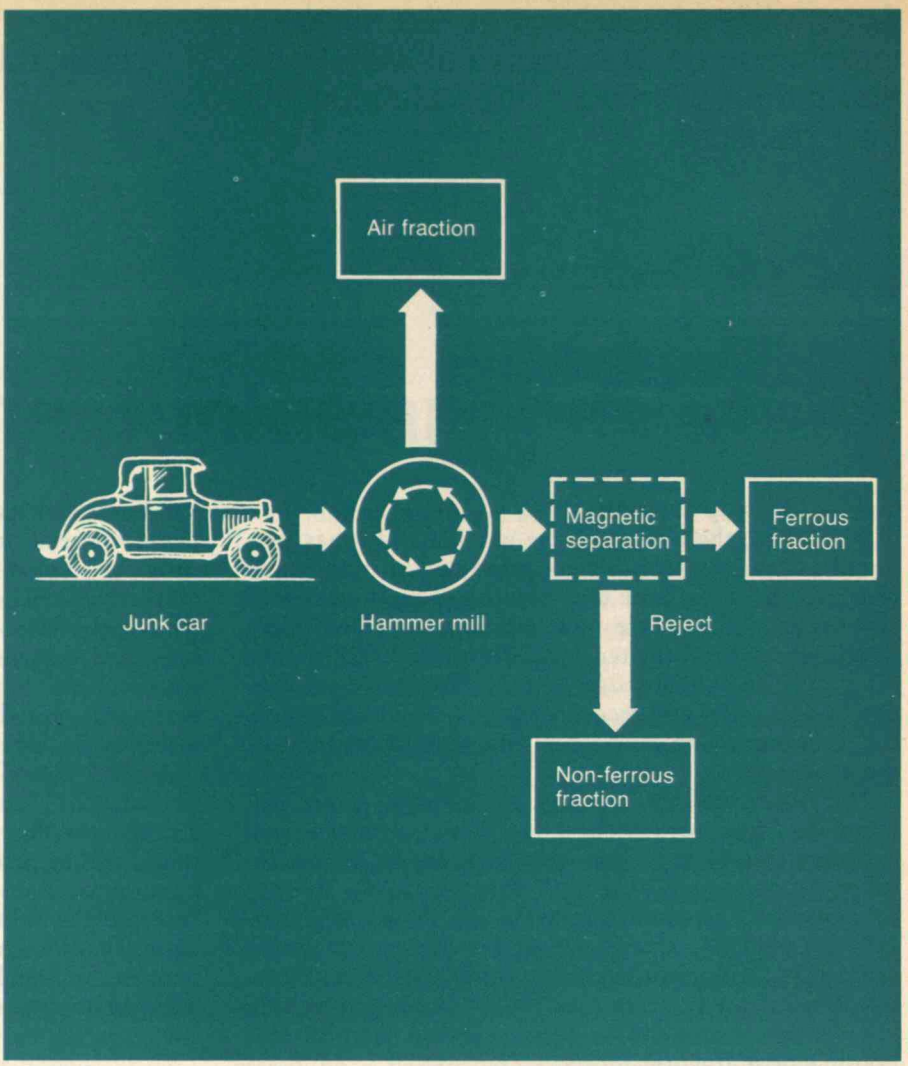
Magnetic Fraction. This fraction consists of the iron and steel fragments that are magnetically recovered from the dense products of the shredded car. More than 95 per cent of the ferrous metals present in the original car are recovered in this fraction. Its high bulk density, its ease of handling, and its homogeneity have led to its high demand for reuse in mills and founderies; and the general rise in scrap prices in recent years has further enhanced its market value. The price of steel scrap has been as high as $140 per ton — a dramatic increase since 1970. The favorable demand and price patterns for the magnetic fraction were important factors in the attraction of investment capital for the commercialization of new technologies for materials recovery from junk cars.

Air-Fraction. This fraction consists of low-density fibrous, plastic and rubber materials present in the junk car. *(See the illustration on page 35.)* It is collected during the shredding process by an air cyclone. Historically, this fraction has been disposed of by landfill. But the rapidly decreasing availability of landfill sites, the increasing costs of disposal, and the increasing volume and changing nature of material products in this waste fraction make its disposal an important future problem.

Opposite page: the vehicle-handling line of an auto-shredder at the Huron Valley Steel Corporation in Belleville, Michigan. The shredder, one of the world's largest, can process hundreds of thousands of junk cars annually. This page: fragments produced by the shredder's operation.



The operation of an auto-shredder is shown in schematic diagram. A junk car is first shredded by a so-called hammer mill. Then scrap of very low density is separated by a strong current of air. From the remaining scrap, a magnetic separator removes a ferrous fraction.



One of the chief ingredients of the air fraction is polyurethane foam, for it is one of the main components of seats, padding at the dash and door panels, and front-seat head rests. Polyurethane foam is also a main ingredient of soft front ends in current vehicles. It is a non-biodegradable, resilient, very low density material — clearly not well suited for landfill disposal. As the illustration on the left of page 36 shows, the average junk car will contain over 20 pounds of polyurethane foam by the end of this decade, and a small mountain of this foam will be generated as waste by each major auto-shredder.

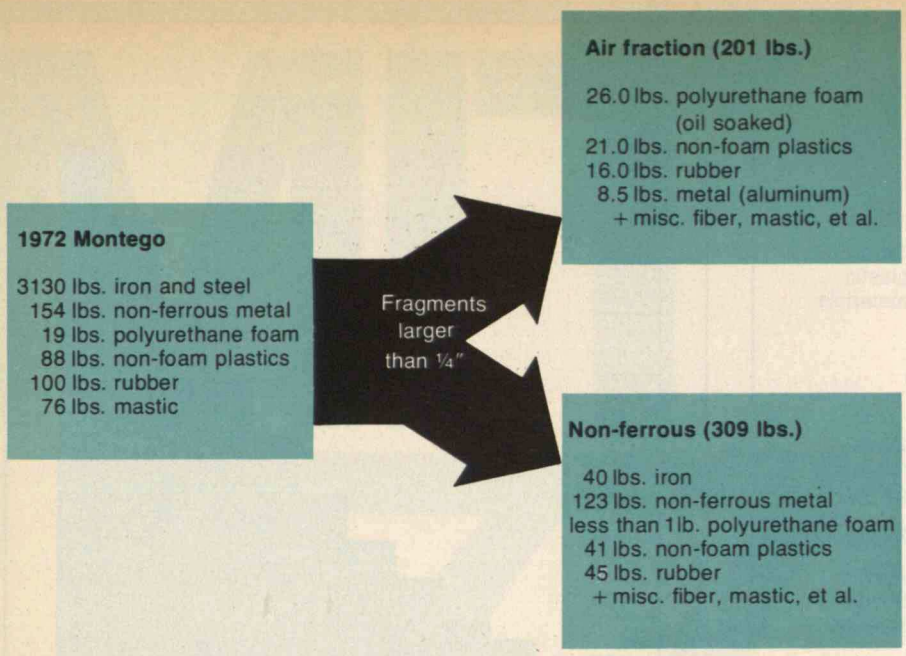
In response to this and similar problems, Ford Motor Company has developed a relatively simple method for hydrolysis of the foam which converts it into a liquid residue whose volume is 20 to 30 times less than that of the original material. Equally important, the liquid consists of a mixture of chemicals that can be utilized for the synthesis of new polyurethane foam or of other industrial chemicals.

Such a polyurethane conversion process could be installed at the auto-shredder or in a non-ferrous recovery plant. However, if the trend continues towards the use of polyurethane, the large percentage of foam waste in the air fraction could come to economically and logistically favor the placing of the conversion process exclusively at the individual car shredders.

Non-Ferrous Fraction. This fraction consists of a complex mixture of fragmented zinc; aluminum; copper and copper wire; stainless steel and small amounts of iron that escaped magnetic separation; and also rubber; plastics; and fibrous material (*see the illustration on the facing page*). Prior to 1970, most shredder operators disposed of this fraction by landfill. To be sure, they employed a simple hand-sorting operation to pick out the larger pieces of non-ferrous metal. But only 28 per cent of the zinc and aluminum and 14 per cent of the copper present in the fraction were recovered by this method. Large amounts of valuable metals were being lost from the industrial system.

In response, undoubtedly, to the rise in scrap price in the early '70s, and also to the related supply shortages which characterized those years, a number of processes have been developed by which more than 95 per cent of the non-ferrous metals present in the shredder fraction can be recovered for reuse. The processes generally involve dense-media separation techniques (the use of liquids of different densities to float off fractions of different specific gravities) which concentrate the aluminum, copper and stainless steel into separate fractions for subsequent refining, if necessary.

Because of individual, proprietary successes in non-ferrous metal recovery techniques, a number of shredding companies have become the "shredder's shredders." In other words, most shredding companies in the U.S. and



Catalog of the air fraction and the nonferrous fraction separated from a 1972 Mercury Montego. The battery, radiator, tires, and gas tank were removed from the car before it was scrapped. The accompanying photograph shows a '72 Montego; the air fraction lies in front of it to the left, and the nonferrous fraction to the right.

Canada now ship their non-ferrous fractions to a few central non-ferrous recovery sites. One of these has now become the world's largest producer of secondary zinc and aluminum. It recovers approximately 25,000 tons per year of each of these metals.

Two future imperatives for recovery of non-ferrous metals are especially important. The first of them is a consequence of the widespread utilization of catalytic converters, starting in 1975, for automotive emission control. This has turned the automotive industry into a dominant consumer of platinum/palladium type precious metal and of stainless steel. For example, the 1975 catalytic converters required as much twelve-per-cent-chromium stainless steels as the steel industry produced in 1973. Unquestionably, techniques will appear for the segregation and recovery of these important resources by the time cars with catalytic converters reach the junk stage in significant numbers.

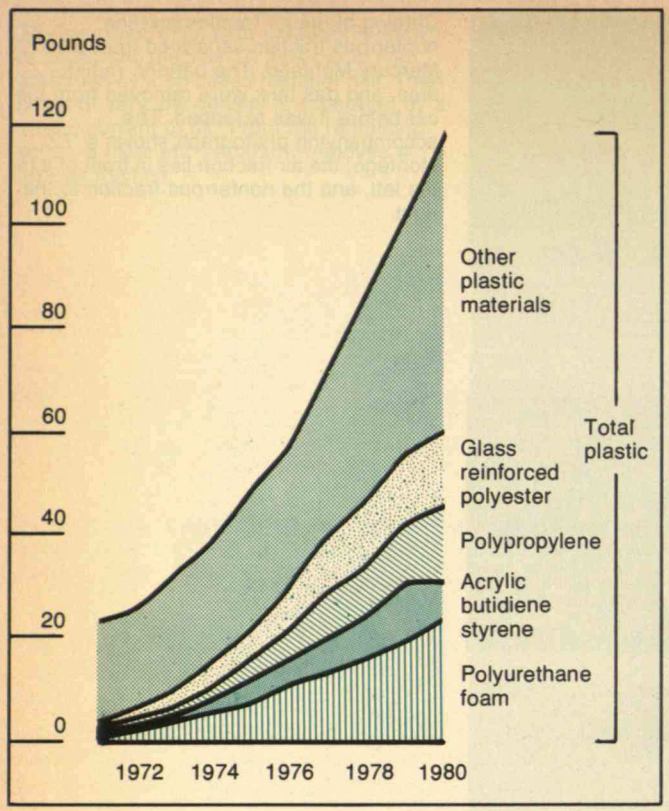
The second imperative concerns aluminum: the interest in vehicles with higher fuel economy has focused considerable attention on the increased utilization of that metal and its alloys. A current vehicle contains about 85 pounds of aluminum on average; there is a strong likelihood that by 1980 this may increase to about 200 pounds, as more aluminum appears in castings for engine and powertrain systems, and in sheet stampings for body exteriors. If this comes about, and if the trend is maintained thereafter, 1 million tons of aluminum per year could be available for recovery from junk cars in the 1990s.

Historically, the recovery of aluminum from scrap has been largely ignored. In 1971, for example, only 4 per cent of the U.S. consumption of aluminum was derived from this source. But recent price trends (including aluminum scrap prices), coupled with concern about our dependence on imports and, most important, recognition that large quantities of energy are saved by using recycled aluminum — all these factors will dictate the emergence of technologies and industrial practices for the separation and recovery of aluminum from automotive vehicles.

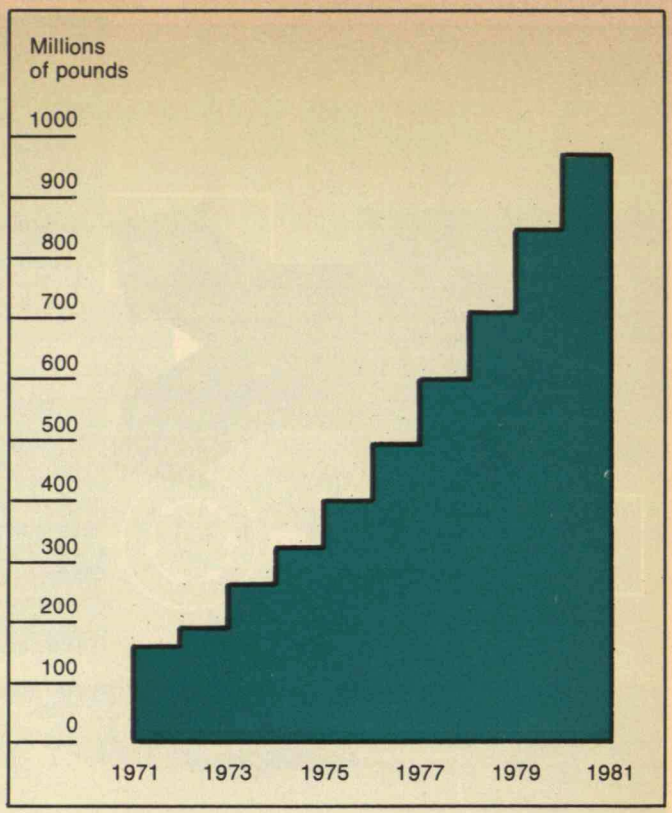
Plastics: Problems and Opportunities

Unquestionably, however, the most demanding and technically exciting challenges will involve the recovery and reutilization of plastics from the junk car. Current vehicles use about 150 pounds of plastic per vehicle. Conservative estimates project about 200 pounds by the end of this decade. It may be more, because of new plastic materials such as fiber-reinforced composites for structural applications.

The typical automobile produced in the early 1970s contained 3 to 4 per cent by weight of plastic materials. This is equal to or somewhat higher than the plastic content of municipal solid wastes. But while there are 20,000 final disposal sites for municipal waste, a high percentage



The average weight of plastic waste per junk car, as projected to 1980 by the Ford Motor Company. As that weight increases, the recycling of plastics will grow in importance.



The total amount of scrap plastic generated from junk cars, assuming that the age distribution of junk cars remains unchanged for the next several years.

	Energy requirement (Million B.t.u.)
Manufacture of metallic materials	80.6
Manufacture of other materials	6.5
Fabrication of parts and assembling of automobile	32.0
Transportation of materials	2.0
Transportation of assembled automobile	0.8
Total energy	**122**

The energy required to manufacture a 1974 Ford (3,600 pounds). The total consumption is 1.22×10^8 B.t.u. Accordingly, if 10 million cars are produced in a year, the total becomes 1.22×10^{15} B.t.u., or 1.5 per cent of the annual U.S. energy consumption.

of cars will ultimately be processed at approximately 125 shredder sites, and then at an even smaller number of non-ferrous recovery sites.

As noted previously, the plastic residue from shredding operations has typically gone into landfill, with little or no attempt at materials recovery. However, with increasing use of plastics in automobiles, and with the new emphasis on conservation of energy and materials, serious attention is now being given to such issues as: the rate at which plastic and polymer waste is generated from future junk cars; the opportunities for efficient resource recovery from this waste, either as energy or as material for reuse; and the new problems appearing in the present junk-car recycling system as a consequence of increased plastic waste.

The illustration just above shows a projection of the total amount of plastic materials to be produced as waste from junk cars through 1981. (The projection assumes that the age distribution of junk cars will remain unchanged for the rest of the decade.) As shown above left, polyurethane foam, polypropylene, ABS plastics, and glass-fiber reinforced polyester thermoset will account for nearly half of the projected plastic waste; but shifting patterns of plastic utilization and increased usage of reinforced composites for structural applications would further complicate the mix.

The recovery of these plastic wastes, as part of the metal recovery operations, would represent a high level of resource recycling. While some success has been achieved, it has come in the concentration of particular fractions of the plastic waste in the laboratory. The technical and economic problems associated with the recovery of homogenous polymer fractions pure enough for direct recycling are difficult and many. Other approaches are under investigation. Perhaps the recovered plastic waste could be converted to fuels, or to alternate feedstock material for manufacture of monomers and modified polymers; or perhaps it could be burned as a heat source or even converted to crude oil.

Energy Considerations

As shown below left, the bulk of the energy involved in the manufacture of an automotive vehicle is the energy required to produce the basic materials which make up a car. Manufacturing and assembly processes together in-

MIT '77

Articles

Departments

Corporate Leadership Awards for Service in the Public Interest to 152 Alumni

Which of M.I.T.'s manifold contributions to American industry is most important?

The answer, without question: people.

Indirectly, because — as of a national survey late in the 1960s — some 10 per cent of all professors of engineering in the U.S. with doctorates earned them at M.I.T. That's more than any other institution in the country, 60 per cent more than the next university.

And directly, because some 75 per cent of M.I.T. alumni make their careers in industry, and the Institute ranks fourth among the nation's universities in the percentage of its alumni who are senior executives.

It was to honor a select group of the latter — 152 alumni who are Chairmen, Vice Chairmen, Presidents, or Managing Partners of major American firms — that brought more than 400 alumni and their guests to the Waldorf-Astoria on December 3. The luncheon was "one of those rare and luminous events where every guest deserves to be at the head table," said Howard W. Johnson, Chairman of the Corporation.

For each of the 152 alumni there was a Corporate Leadership Award, marking him, through his responsibilities in private industry, as "an exceptional contributor to the strength and well-being of this nation," said the resolution by which the M.I.T. Corporation had authorized the Awards.

"Thousands of M.I.T. alumni have served in leadership positions in small and large companies throughout the world," said the Corporation resolution. "In thus serving the public interest, many have also advance innovative concepts of private enterprise in founding successful companies which they have headed.

More than 200 of M.I.T.'s most distinguished sons and daughters were guests of the M.I.T. Corporation — with Howard W. Johnson (right), its Chairman, acting as host — at the Waldorf-Astoria on December 3. The purpose was to honor with Corporate Leadership Awards 152 alumni who are Chairmen, Vice Chairmen, Presidents, or Managing Partners of major American firms. The picture shows Mr. Johnson congratulating one of those — George P. Shultz, Ph.D. '49, President of Bechtel Corp. — with another old friend, J. Kenneth Jamieson, '31, a Life Member of the Corporation who was formerly Chairman of Exxon Corp., looking on. (Photo: Calvin Campbell)

"As a fountainhead of new ideas and advanced education for leadership in science, engineering, management, architecture, and related fields, M.I.T. properly honors the achievement of awardees. In doing so, the Corporation symbolically expresses its esteem and abiding appreciation to M.I.T. alumni everywhere, who further the public account daily through exemplary conduct of corporate enterprise."

Mastering Superheated People and Things

George P. Shultz, Ph.D. '49, who as President of Bechtel Corp. was one of the awardees, spoke of M.I.T.'s "preeminence in laboratory and classroom, as a center of learning in science and technology, and in the production of people who can do practical things." Opening his luncheon address (*see left*), Dr. Schultz said he believes M.I.T. is "unique in the interplay between laboratory and classroom and the practical world."

Carl M. Mueller, '41, Managing Partner of Loeb Rhoades and Co., expressed his indebtedness to M.I.T. by recalling his struggles as an undergraduate in mechanical engineering to master the Keenan steam tables. "Water gone crazy with the heat," he said, and it was a good training for today "when people and things have gone crazy with the heat."

Fresh from a meeting of the Corporation in New York earlier that day, Mr. Mueller — he also received a Corporate Leadership Award — said he took "delight" in "confirming that the spirit of M.I.T. is intact and thriving.

"Over and over again," he said, "men and women looking about for what is important in the nation have chosen to endow M.I.T. . . . I have never observed the Institute and its faculty at a higher level of achievement."

"Extraordinary Quality," "Creative Tensions"

Reviewing the many ways in which M.I.T. seeks to augment its relationships with industry, President Jerome B. Wiesner did not hesitate to speak of one as paramount contribution: "the privilege of bringing our students and faculty together . . . extraordinary quality on both sides," he said. President Wiesner spoke of "the complex interaction . . . made possible by a private institution and private industry, and leading to constructive tensions and interactions."

While M.I.T. students are learning the details of their own professional fields, Dr. Wiesner said, they also come to understand "current economic and social complexities." Thus they're prepared, he said "to exercise effective and responsible leadership in the future," a program whose effectiveness is assured by "the Institute's critical balance of public and private funding."

The Four Key Conflicts: Independence, Equity, Resources, and Inflation

How to judge President Jimmy Carter in the next few months?

Watch how well he understands four "clusters of problems" which now confront world leaders, says George P. Shultz, Ph.D. '49, President of Bechtel Corp.

These are the four, as listed by Dr. Shultz — he was Secretary of Labor, Director of the Office of Management and Budget, and Secretary of the Treasury between 1969 and 1973 — at the M.I.T. Corporate Leadership Luncheon in New York on December 3 *(see right)*:

☐ The conflict between the world's growing interdependence and many nations' drives for security and independence. The former is emphasized by world trade now running at about $1 trillion annually, the latter by "a new sense that we must look to security in our sources of supplies."

☐ The conflict between the goal of economic efficiency and the growing concern for "a vaguely defined notion of equity." Put in conventional terms, said Dr. Shultz, "the businessman is driving to get the efficient solution while the politician is driving to get . . . the equitable solution."

☐ The conflict between the developing nations, which have a gradually tightening monopoly on raw materials, and the developed nations which are increasingly dependent on imported resources, with the poorest "third world" nations the hapless victims. The "creative" solution which thus far escapes us is "a way to grapple with the development problems of the poorest countries . . . without . . . messing up the vital raw materials aspect of our world economy."

☐ The crucial problem of inflation and economic growth. It's not really what is called stagflation, said Dr. Schultz, not really "the classic trade-off between inflation and unemployment. . . . It is more a 'trade-on': . . . if we can control inflation the employment situation is going to get healthier, and if we cannot it is going to get worse."

On how well it seems to understand these four problems may be judged "how well our next administration will do in general," said Dr. Shultz. And he is optimistic, he said, because he is convinced that, "in many cases, people are ready for discipline. . . . The world may be ready for we might call 'a new realism,' " Dr. Schultz told his audience.

A special role for M.I.T. in this context, said Dr. Shultz: "Flowing from the practical world to the M.I.T. campus are ideas about the kinds of knowledge needed . . . and from the campus there come ideas about how to think problems through a little more completely . . . an extraordinary contribution to the interplay between the world of the laboratory and the classroom on the one hand and the practical world of work on the other."

When Industry Turns to M.I.T. for Research

Five trends in industry's sponsorship of research at M.I.T., said Thomas F. Jones, Sc.D. '52, Vice President for Research, speaking late last fall to members of the Corporation Development Committee:

☐ In sponsoring research, industry is increasingly concerned with gaining new ideas and decreasingly with obtaining exclusive rights; it is a view consistent with M.I.T.'s attitude that research is "the ultimate educational tool" — and welcome indeed on the campus, said Dr. Jones.

☐ Management is recognizing that its own research and development laboratories "tend to be bogged down by fire-fighting, problem-solving, and the limitations of the current product line." So academic laboratories are regarded as "sources of future options," another attitude welcome on the M.I.T. campus.

☐ M.I.T. is especially sought by industry as a source of "credible information" for policymaking in relation to government programs — energy policy, for example.

☐ There is increasing awareness of M.I.T. as a potential element in corporate and industrial renewal — as a source of new directions for a company and even for an industrial group. An example is the consortium from the plastics industry working with Nam P. Suh, '59, Professor of Mechanical Engineering, on new polymer materials and processes.

☐ Undergraduates are suddenly in the spotlight, thanks to the Undergraduate Research Opportunities Program (U.R.O.P.) and the Innovation Center; industries now recognize that students can be the source of vital, new ideas, said Dr. Jones.

In five years, research under industrial sponsorship at M.I.T. has increased from an annual rate of $1.6 million to $6 million. Dr. Jones admits the volume is still "modest," but he calls the growth rate "significant."

At the Starlight Terrace of the Waldorf-Astoria (top) on December 3, the M.I.T. Corporation presented 152 Corporate Leadership Awards to alumni in leading roles in America's leading businesses. Among those present: (opposite) Edward R. Kane, Ph.D. '43, and Mrs. Kane with Robert A. Alberty, Dean of the School of Science; (left, above) William S. Brewster, '39, with President Jerome B. Wiesner; (right, above) Howard F. Carver, '32; (left, below) Frank A. Jones, '48; and (right, below) Robert L. Johnson, '38, with Chairman Howard W. Johnson.

"Extraordinary Achievements . . . as Leaders of Business and Industry"

The following are the 152 M.I.T. alumni designated by the Corporation to receive Corporate Leadership Awards on December 3 — alumni who have primary executive responsibility for leading American industries and financial, professional, and construction firms. The Awards recognize "the truly extraordinary achievements of M.I.T. alumni as leaders of business and industry," said Howard W. Johnson, Chairman of the Corporation; and they also "give M.I.T. an unusual opportunity to pay tribute to the significance of creative and effective leadership in business and industry in our national life, and the role of the private enterprise system in our national character and well-being."

Joseph F. Alibrandi, '52
President and Chief Executive Officer
Whittaker Corp.

Bennett Archambault, '32
Chairman and President
Stewart-Warner Corp.

Angelo R. Arena, '49
Chairman
Neiman-Marcus Co.

A. Donald Arsem, '44
Chairman of the Board and Chief Executive Officer
Wurlitzer Co.

David Bakalar, Sc.D. '51
President
Transitron Electronic Corp.

W. Gardner Barker, S.M. '37
Chairman and Chief Executive Officer
Thomas J. Lipton, Inc.

Edward E. Barr, '69*
President
Sun Chemical Corp.

Shepard Bartnoff, Ph.D. '49
President
Jersey Central Power and Light Co.

Morrison H. Beach, '42
Chairman and Chief Executive Officer
Travelers Corp.

David W. Bernstein, '31
Chairman, President, and Chief Executive Officer
American Biltrite, Inc.

Howard W. Blauvelt, '56*
Chairman and Chief Executive Officer
Continental Oil Co.

Gerhard D. Bleicken, '58*
Chairman and Chief Executive Officer
John Hancock Mutual Life Insurance Co.

Kenneth E. Bowen, S.M. '53
President
Central Illinois Public Service Co.

William S. Brewster, '39
Vice Chairman
Emhart Corp.

Rowland C. W. Brown, '69*
President and Chief Executive Officer
Buckeye International, Inc.

Harry W. Buchanan, S.M. '56
President and Chairman of the Board
Virginia Chemicals, Inc.

George M. Bunker, '31
Chairman
Martin Marietta Corp.

Gordon Bunshaft, '33
Partner
Skidmore, Owings and Merrill

Alfred E. Busch, '37
Chairman of the Board
Keuffel and Esser Co.

Eugene A. Cafiero, S.M., '60
President
Chrysler Corp.

Dennis J. Carney, Sc.D., '49
President
Wheeling-Pittsburgh Steel Corp.

Thomas S. Carroll, '42
President and Chief Executive Officer
Lever Brothers Co., Inc.

Howard F. Carver, '32
Chairman
Gleason Works

David R. Clare, '45
President and Chairman of the Executive Committee
Johnson and Johnson

Albert F. Clear, Jr., '42
President
Stanley Works

Emilio G. Collado, '31
President
Adela Investment Co., S.A.

Paul M. Cook, '47
President
Raychem Corp.

Ralph E. Cross, '33
President and General Manager
Cross Co.

Robert K. Deutsch, '40
President
L. D. Schreiber Cheese Co., Inc.

Charles Diebold, III, '58
Chairman and President
Western New York Savings Bank

Mario A. DiFederico, '47
President
Firestone Tire and Rubber Co.

Irénée du Pont, Jr., '43
President and Chief Executive Officer
Christiana Securities Co.

David K. Easlick, '55
President
Michigan Bell Telephone Co.

William S. Edgerly, '49
President
State Street Boston Financial Corp.

James L. Everett, S.M., '59
President
Philadelphia Electric Co.

Robert R. Everett, S.M., '43
President
Mitre Corp.

Herman H. Ferré, '31
President
Puerto Rico Iron Works

Leo J. Feuer, '43
President
William Carter Co.

Henry E. Fish, S.M., '61
President
American Sterilizer Co.

Langdon S. Flowers, '44
Vice Chairman and Chief Executive Officer
Flowers Industries, Inc.

John M. Fluke, S.M., '36
Chairman and Chief Executive Officer
John Fluke Manufacturing Co., Inc.

Raymond C. Foster, '41
Chairman
Stone and Webster, Inc.

Roger M. Freeman, Jr., '44
President
Allendale Mutual Insurance Co.

Charles C. Gates, '43
Chairman and President
Gates Rubber Co.

Joseph G. Gavin, Jr., '41
President and Chief Operating Officer
Grumman Corp.

W. H. Krome George, '40
Chairman and Chief Executive Officer
Aluminum Co. of America

John H. Gerstenmaier, S.M., '52
President
Goodyear Tire and Rubber Co.

Ivan A. Getting, '33
President
Aerospace Corp.

Robert L. Gibson, S.M., '55
President and Chief Executive Officer
California Canners and Growers

Robert S. Gillette, '36
Chairman
National Life Insurance Co.

Maurice F. Granville, S.M., '39
Chairman and Chief Executive Officer
Texaco, Inc.

Frank J. Graziano, S.M., '45
President and Chief Executive Officer
Crompton and Knowles Corp.

Eugene C. Gwaltney, '41
President and Chief Executive Officer
Russell Corp.

John C. Haas, S.M. '42
Chairman
Rohm and Haas Co.

T. Marshall Hahn, Jr., Ph.D., '50
President
Georgia-Pacific Corp.

William E. Hartmann, '37
Partner
Skidmore, Owings and Merrill

Ralph Hayden, Jr., '33
Chairman
Foxboro Co.

Oliver G. Haywood, Sc.D., '40
Chairman of the Board
Huyck Corp.

Ralph L. Hennebach, S.M., '53
President
Asarco, Inc.

William R. Hewlett, S.M., '36
President and Chief Executive Officer
Hewlett-Packard Co.

Albert P. Hildebrandt, '44
Chairman
Mayhill Homes Corp.

Sidney C. Howell, '49
President and Chief Operating Officer
Weatherhead Co., Inc.

Rudolph Hurwich, '43
Chairman
Dymo Industries, Inc.

Franklin M. Jarman, '53
Chairman and Chief Executive Officer
Genesco, Inc.

Byron E. James, '32
Chairman
McQuay-Perfex, Inc.

Robert L. Johnson, '38
President
Arkwright-Boston Insurance Co.

Frank A. Jones, '48
President
Cook Industries, Inc.

Edward R. Kane, Ph.D., '43
President
E. I. du Pont de Nemours and Co., Inc.

William W. Keefer, '50
President
Warner Electric Brake and Clutch Co.

George M. Keller, '48
Vice Chairman
Standard Oil Co. of California

Lester L. Kilpatrick, S.M., '48
Chairman
California Computer Products, Inc.

Semon E. Knudsen, '36
Chairman
White Motor Corp.

Charles G. Koch, '57
Chairman and President
Koch Industries, Inc.

Herbert W. Kochs, '24
Chairman
Diversey Corp.

David I. Kosowsky, Sc.D., '55
President
Damon Corp.

Richard T. Kropf, '31
President
Belding Heminway Co., Inc.

Ralph Landau, Sc.D., '41
Chairman and
Chief Executive Officer
Halcon International, Inc.

Gerald D. Laubach, Ph.D. '50
President
Pfizer, Inc.

Edward C. Levy, Jr., '52
President
Edward C. Levy Co.

Walter F. Limbach, '45
President
Limbach Co.

Samuel E. Lunden, '21
Partner
Lunden and Johnson

Wilfred D. MacDonnell, '34
Chairman and
Chief Executive Officer
Kelsey-Hayes Co.

William C. MacInnes, '26
Chairman of the Board
Tampa Electric Co.

Lee Martin, '42
Chief Executive Officer
Nibco, Inc.

Jerry McAfee, Sc.D., '40
Chairman and
Chief Executive Officer
Gulf Oil Corp.

William J. McCune, Jr., '37
President and
Chief Operating Officer
Polaroid Corp.

James S. McDonnell, Jr., '25
Chairman
McDonnell Douglas Corp.

Kenton E. McElhattan, '68*
Chairman and President
National Mine Service Co.

Denman K. McNear, '48
President
Southern Pacific Transportation Co.

David A. Meeker, '24
Chairman
Hobart Corp.

William C. Mercer, S.M. '56
President and
Chief Executive Officer
New England Telephone
and Telegraph Co.

John O. Merrill, Jr., '49
Partner
Skidmore, Owings and Merrill

E. Kirkbride Miller, '41
Chairman
T. Rowe Price Associates, Inc.

Frank R. Milliken, '34
President and
Chief Executive Officer
Kennecott Copper Corp.

Henry T. Mudd, S.M., '38
Chairman and
Chief Executive Officer
Cyprus Mines Corp.

Carl M. Mueller, '41
Managing Partner
Loeb, Rhoades and Co.

Clint W. Murchison, Jr., S.M., '44
Partner
Murchison Brothers

Alfred J. Murrer, '48
President and
Chief Executive Officer
Gleason Works

Walter A. Netsch, Jr., '43
Partner
Skidmore, Owings and Merrill

Guy W. Nichols, S.M., '61
President and
Chief Executive Officer
New England Electric System

Robert N. Noyce, Ph.D., '53
Chairman
Intel Corp.

Bernard J. O'Keefe, '45
Chairman and President
E. G. and G., Inc.

Kenneth H. Olsen, '50
President
Digital Equipment Corp.

Robert C. O'Neill, Ph.D., '50
President
Cooper Laboratories, Inc.

Nathan R. Owen, '41
Chairman and
Chief Executive Officer
General Signal Corp.

Thornton W. Owen, '26
Chairman
Perpetual Federal Savings
and Loan Association

Bernard G. Palitz, '47
Chairman
Commercial Alliance Corp.

I. M. Pei, '40
I. M. Pei and Partners

Peter G. Peterson, '46
Chairman and
Chief Executive Officer
Lehman Brothers

James C. Phelps, '61*
President
Tesoro Petroleum Corp.

Harold W. Pope, '39
Chairman
Sanders Associates, Inc.

Donald E. Procknow, '63*
President
Western Electric Co.

James R. Reese, '52
President
Hydrometals, Inc.

Robert B. Semple, '32
Chairman
BASF Wyandotte Corp.

H. Robert Sharbaugh, S.M., '61
Chairman and
Chief Executive Officer
Sun Co., Inc.

Harold A. Shaub, '57*
President
Campbell Soup Co.

George P. Shultz, Ph.D., '49
President
Bechtel Corp.

Robert E. Siegfried, S.M., '47
President and
Chief Executive Officer
Badger Co., Inc.

Richard P. Simmons, '53
President
Allegheny Ludlum Steel Corp.

Henry E. Singleton, '40
Chairman and
Chief Executive Officer
Teledyne, Inc.

S. Bruce Smart, Jr., S.M., '47
President and
Chief Operating Officer
Continental Group, Inc.

Charles H. Smith, Jr., '42
Chairman and
Chief Executive Officer
Sifco Industries, Inc.

Goff Smith, S.M., '53
President and
Chief Executive Officer
Amsted Industries, Inc.

Phillip H. Smith, Met., '52
Chairman, President,
and Chief Executive Officer
Copperweld Corp., Inc.

Roger P. Sonnabend, '46
Chairman
Sonesta International Hotels Corp.

Arthur S. Spear, '41
President and
Chief Executive Officer
Mattel, Inc.

Richard D. Spence, '62*
President and
Chief Operating Officer
Consolidated Rail Corp.

James I. Spiegel, '64
President
Kayser-Roth Corp.

S. James Spitz, Jr., '43
President and
Chief Operating Officer
International Flavors
and Fragrances, Inc.

J. Lamar Stall, S.M., '60
President
Southwestern Electric Power Co.

John C. Stetson, '43
President
A. B. Dick Co.

William C. Tallman, '42
President
Public Service Co. of New
Hampshire

Richard L. Terrell, '58*
Vice Chairman
General Motors Corp.

Harold E. Thayer, '34
Chairman, President,
and Chief Executive Officer
Mallinckrodt, Inc.

Harold Thorkilsen, '45
President and
Chief Executive Officer
Ocean Spray Cranberries, Inc.

George S. Trimble, '36
President and
Chief Executive Officer
Bunker Ramo Corp.

William E. Tucker, Jr., S.M., '42
President
Caltex Petroleum Corp.

George P. Turci, S.M., '56
President
American Bakeries Co.

Howard S. Turner, Ph.D., '36
Chairman and
Chief Executive Officer
Turner Construction Co.

C. Vincent Vappi, '48
President
Vappi and Co., Inc.

Dean K. Webster, Jr., '19
Chairman of the Board
H. K. Webster Co., Inc.

Walter N. Webster, '23
Co-Chairman of the Board,
H. K. Webster Co., Inc.

Harry M. Weese, '38
Harry M. Weese and Associates

William J. Weisz, '48
President and
Chief Operating Officer
Motorola, Inc.

Willis S. White, Jr., S.M., '58
Chairman and
Chief Executive Officer
American Electric Power Co., Inc.

Thomas R. Williams, S.M. '54
Chairman of the Board
First National Bank of Atlanta

Thornton A. Wilson, '53
Chairman of the Board and
Chief Executive Officer
Boeing Co.

Frank S. Wyle, '41
Chairman of the Board and
Chief Executive Officer
Wyle Laboratories

Leopold S. Wyler, Jr., '42
Chairman of the Board
TRE Corp.

St. Clair P. Yates, '38
President
Yates Petroleum Corp.

Richard B. Young, '38
President
Acushnet Co.

William R. Zimmerman, '48
President
Monogram Industries, Inc.

* Program for Senior Executives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Opposite page: Robert Currier, '79, followed by Don Devine, '79, during a soccer match with the Coast Guard Cadets. (Photo: Richard F. Reihl, '78.)

Varsity Athletics Fall Season Finest in Years

by David A. Dobos, '77

M.I.T. varsity athletics enjoyed one of its finest fall seasons in years in 1976. Teams in cross country, water polo, soccer, and women's volleyball compiled a combined 41-16-1 record against regular-season opponents with cross country and women's volleyball earning berths to post-season competitions.

Champions of the East

The women's volleyball team highlighted the varsity program, posting a perfect 25-0 record and capturing the Metropolitan Boston, Massachusetts State, and Eastern United States championships. In winning the latter, the women qualified for the Association for Intercollegiate Athletics for Women (A.I.A.W.) Division II (small college) National Championships held on December 7-11 at Pepperdine University in Malibu, California. Only 20 colleges were selected for the tournament. Their bid to reach the final double-elimination round was thwarted by Lewis and Clark College of Idaho, who edged out the Tech squad.

M.I.T. defeated the University of Maryland at Baltimore and York, Penn., in straight games and later topped host Mansfield State, Penn., in the finals to earn the Easterns championship. The team members were especially satisfied with the title because the Easterns selection committee had bypassed them in 1975, when M.I.T. had posted a 17-1 record and captured its first state championship.

A key to M.I.T.'s success is second-year coach Dave Castanon, who just received his Ph.D. in applied mathematics from the Institute last summer. In two years, he has coached the squad to a 42-1 regular season record. His ability to pinpoint each foe's strengths and weaknesses and then coach his athletes to compensate for or take advantage of those respective characteristics is outstanding. M.I.T. defeated every Massachusetts Division I (major college) team it faced, including the University of Massachusetts, Springfield College, and Bridgewater State.

Fighting Snow and Cold in an Early Fall

Senior Captain Frank Richardson, '77, led the cross country squad to its finest season since 1968. Richardson earned All-American honors for the third consecutive year and became M.I.T.'s first ever I.C.A.A.A.A. individual champion as the harrier team compiled a 7-1 dual meet record and placed fourth in both the Codfish Bowl (28 teams) and the Greater Boston Championships. Such stellar performances enabled M.I.T. to be selected as one of the six schools to represent the New England small colleges at the N.C.A.A. Division III National Championships hosted by Case Western Reserve, in Cleveland, on November 13.

In that meet, Richardson braved snow and freezing temperatures to place fourth individually, one position better than his 1975 performance. He was the only runner from last year's top five to finish among the 1976 leading quintet. He qualified for the N.C.A.A. University Division Nationals at North Texas State University on November 22.

Two days after earning All-American honors, Richardson scorched Van Cortland Park's 5.0-mile course in 25:05 to capture the IC4A small college individual championship. He sprinted by his last competitor at the crest of the last hill, holding him off throughout the final 1,000-yard straightaway in an exciting finish, for the victory. This performance singled him out as M.I.T.'s premiere cross country runner, the finest distance ace ever for the Institute.

The harriers opened the 1976 season by retaking the Engineers Cup from Rensselaer Poly and Worcester Poly in Troy, N.Y. Lowell was the only team that could stop the Engineers as they went on to defeat Coast Guard, Wesleyan, Boston College, Williams, and Tufts.

Coach Peter Close, whose teams have compiled a career 30-13 dual meet mark, had nothing but praise for the Engineer harriers. Seven varsity athletes broke 26:00 on Franklin Park's 5.0-mile course, a first for M.I.T.

On the Way Up in Soccer and Polo

Soccer coach Walt Alessi was somewhat disappointed in the pitchmen's 4-7-1 record, but noted significant improvement over the 2-8-1 mark of 1975. Victories over Clark, Boston College, Lowell, and Colby highlighted the season. The Engineers scored as many goals (24) as did their opponents, erasing the adverse 17-40 split of last year.

Captain and M.V.P. Frieder Krups, '77, (Solingen, Germany), Zanda Ilori, '79, (Kwara State, Nigeria), and Rob Currier, '79, (Coco Solo, Canal Zone) all made the Greater Boston League All-Star squad.

Alessi noted that most of the team were sophomores and that it was this inexperience that kept M.I.T. from a more successful season. With nine of ten starters returning, he looks to a possible Greater Boston League title in 1977. His optimism is well-founded because only one league team defeated the Engineers by more than one goal in 1976.

Water polo also completed a much improved season over 1975. Despite having only two of seven starters with high school experience, the John Benedick coached team still managed a respectable 5-8 record.

Benedick, in his second year, pointed to an overtime upset victory against Boston College as the highlight of the season. The Engineers also made close games against teams with which they were not even competitive last year. Harvard was forced into overtime before finally downing a stubborn M.I.T. squad. The University of Massachusetts could only edge the Engineers by three goals.

One reason for M.I.T.'s success was goalie Pete Griffith, '79, (Palos Verdes, Calif.). Griffith's ability to perform when needed earned him the team M.V.P. award. Benedick felt that Griffith could have attained All-New England honors had M.I.T. qualified for that tournament. Also cited for their contributions to the team were Tim Eggert, '80, Sam Senne, '78, John Dolan, '80, Dick Henze, '78, and most improved players Ken Calvert, '79, and Eli Wylen, '78.

Benedick noted that his athletes had reached the level of playing ability and awareness that, with hard work during next spring's scrimmage matches, they could develop into one of New England's finer teams by next fall.

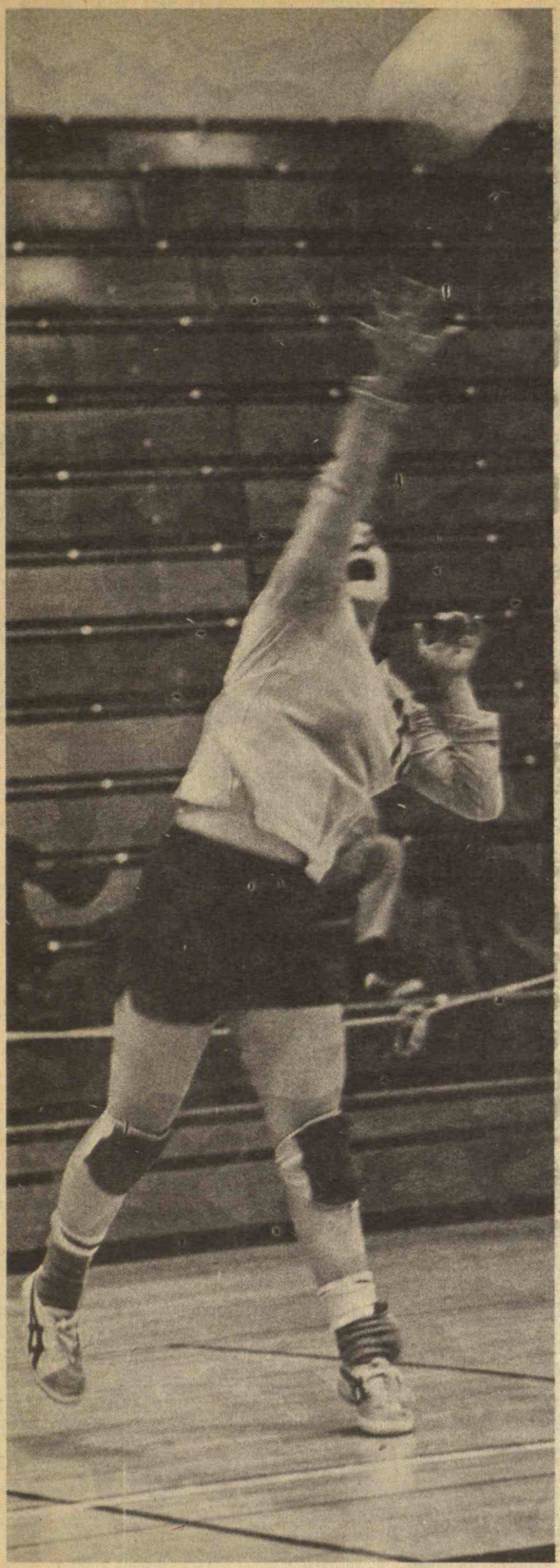
In one of their finest games in many years, the Engineer soccer team played Babson, the defending N.C.A.A. Division III champions, to a standstill for over 60 minutes before going down to a hard-fought defeat. Lampros Fatsis, '77, (opposite page, top right) rushes in as Babson's Shane Kennedy makes the save. Alex Ilroi, '79, (left), was a mainstay of the Engineers' defense.

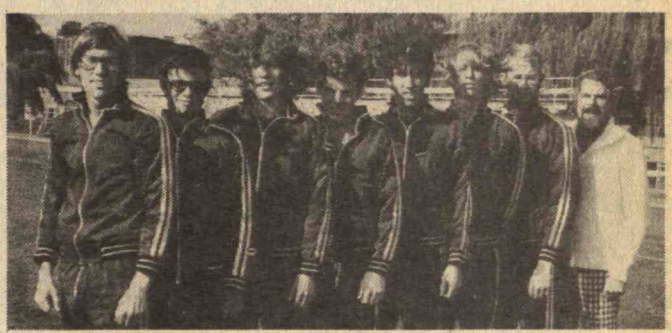
Lisa Jablonski, '77, (right) spikes a shot during the Eastern Volleyball Championships in Mansfield, Penn. With nine straight successful serves, Ms. Jablonski led the team to a tie from an 11-2 deficit in a game they eventually lost to Mansfield State. The team went on to win the championship, but their bid to reach the final double-elimination round of the national championships in California was thwarted.

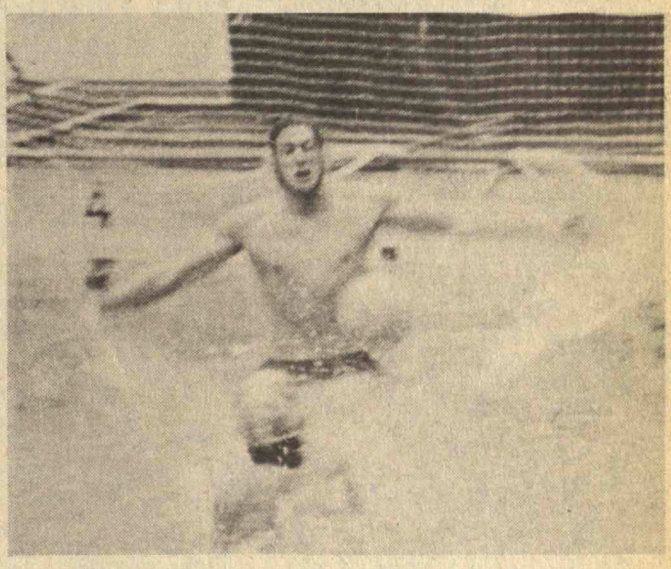
Above: Portland and M.I.T. rugby players vie for the ball on a rain-drenched Brigg's Field.

Opposite page, second from top: the M.I.T. 1976 varsity cross country team, from left to right: Frank Richardson, '77, Barry Bayus, '79, Dave Westenbery, '80, John Krolewski, '77, Len Nasser, '80, Chris Svendsgaard, '78, Steve Keith, '77, and coach Pete Close.

Opposite page, bottom: Engineer goalie Peter Griffith, '79, saves a shot by an Exeter attacker in an M.I.T. water polo victory at the Alumni Pool. (Photos: Mark H. James, '78, Gordon R. Haff, '79, John Bradstreet, '80, and Jet Photo.)







"Whoooo's here? The barred owl of Killian Court," quipped *Tech Talk* early this winter in the caption to this photograph by Calvin Campbell of the M.I.T. News Office. The owl was in fact a resident of Killian Court for several weeks during December, where he posed agreeably for countless camera buffs and bird watchers.

Radiation Laboratory Alumni Recall Their Age of Innocence, Arrogance, and Achievement

Early in October, 1940, James R. Killian, Jr., '26, who was sitting in the President's Office as Karl T. Compton's assistant, had a telephone call from his boss, then in Washington.

Could 15,000 square feet of space be found somewhere at the Institute for a special government research project? asked Dr. Compton.

Dr. Killian recalls his cautious answer — that "I thought it would not be easy." But within 24 hours the space had been found, and by November two men named Isidor Rabi and Lee A. DuBridge had moved in. They brought with them a 10-centimeter "cavity" magnetron which a British mission had brought to Washington six weeks earlier. It was to be the foundation of all the microwave radar developed at M.I.T. during the next five years — and that, in turn, was the source of at least half of the radar used by the U.S. armed forces in World War II.

In that extraordinary period M.I.T. was gradually transformed from an institute of technology into a security-conscious beehive of classified research involving over 6,000 people and 15 acres of the campus. Five years later it suddenly emerged as a great national resource — a new kind of university polarized around science and technology.

These five years of history came alive last fall for more than 200 "alumni" of the Radiation Laboratory and their guests who assembled at the Institute for a reunion of reminiscence and party. It was "no particular anniversary," said President Jerome B. Wiesner — he was one of the hundreds of scientists drawn to M.I.T. by this magnetron and its by-products; Professor Albert G. Hill "just thought we should have a reunion . . . while we could still dance."

Dr. DuBridge, who went on to become President of California Institute of Technology after his five years as Radiation Laboratory Director, remembers it all with great pride — a remarkable assemblage of talent and a great heritage of technology. The Radiation Laboratory gave the nation four out of seven Science Advisers to the President, and since its organization all but two of the Presidents of Caltech and M.I.T. have come from among its alumni.

Dr. Rabi remembers the beginning as a moment of innocence — physicists turning to technology and to warfare, about neither of which they knew much — and arrogance: "whatever we did was right," because no one told them precisely what to do, and no one knew. "An enormous opportunity" and "a great achievement," he said — and, unlike some other World War II projects — a result in which everyone takes pride. "It is wholly remarkable to have worked on a weapons system and have such a positive feeling about the achievement and its value," thinks Dr. Rabi, who, before the end of the war, had begun an involvement with the Manhattan Project and what turned out to be the atomic bomb.

Lincoln Laboratory After 25 Years: "The Epitome of Genius and Dedication"

On its 25th anniversary last November 1, M.I.T.'s Lincoln Laboratory was described by General William J. Evans, U.S.A.F., Chairman of the Joint Advisory Committee which oversees the Laboratory's work for the armed services, as "the epitome of the genius and dedication of the U.S. science and technical community."

It was a day of congratulations for all concerned with the Laboratory, a government-sponsored center operated by M.I.T. in Lexington, Mass., for research and development in advanced electronics with special emphasis on defense applications.

☐ Gerald P. Dinneen, Director of the Laboratory, was praised by Paul E. Gray, '54, Chancellor of the Institute, for "his singleminded concern for quality and excellence . . ."

☐ Thomas C. Reed, Secretary of the Air Force, gave President Jerome B. Wiesner the Department of Defense's Meritorious Award for the Laboratory's "outstanding technological support — . . . a key role in . . . new airborne, ground, and satellite-system communication as well as advanced radar, reconnaissance, and laser techniques." Despite its past record, said Mr. Reed, Lincoln's "finest hour may be in the future. Technology is our main fortification,

Why have a Radiation Laboratory reunion? Because "it was about time," says Albert G. Hill, former Vice President for Research who was the last Head of Radiation Laboratory's Division 5. So he brought together the leadership of that remarkable World War II research effort for an afternoon and evening of reminiscence and good fellowship late last fall. In the top picture are (left to right) James R. Killian, Jr., '26, who then was Acting President of M.I.T.; Lee A. DuBridge, Director of the Laboratory; Isidor I. Rabi, Associate Director; Dr. Hill; and President Jerome B. Wiesner. In the lower picture, President Wiesner examines an early klystron — the radio-frequency generator which made radar possible — with Edward M. Purcell, Professor of Physics at Harvard. Slides and movies of Radiation Laboratory days were enlivened by a series of limericks (below) written by the late L. A. Turner of its staff.

An able young prexy named Karl
Could untangle most any bad
quarrel
But when N.D.R.C.
Settled at M.I.T.
The mess took five years to
unsnarl

Five dignitaries posed for this picture at the 25th birthday party of M.I.T.'s Lincoln Laboratory on November 1, when the Department of Defense's Meritorious Award was presented to M.I.T. and the Laboratory for its key role in developing "electronic techniques and advanced devices . . . to support [U.S.] weapons systems." But the thrust of the ceremonies was to pay tribute to the Lincoln Laboratory staff "who have faith in its mission and who, through their own strivings for excellence, make possible the continuing excellence of the Laboratory," said Chancellor Paul E. Gray, '54. Left to right in the picture are Dr. Gray; Gerald P. Dinneen, Director of the Laboratory; General William J. Evans, U.S.A.F., Commander of the Air Force Systems Command; President Jerome B. Wiesner; and Thomas C. Reed, Secretary of the Air Force.

The man on the left is Professor David Epstein, Conductor of the M.I.T. Symphony Orchestra; on the right is Alfred E. Vellucci, Mayor of Cambridge. An unusual combination in a single photograph, and the occasion was unusual, too: a special "Salute to Cambridge" concert by the Orchestra at which some 700 Cambridge residents were guests late last fall. Speaking during the intermission, Walter A. Rosenblith, Provost of M.I.T., and Mayor Vellucci compared M.I.T. and Cambridge to a duet in which two artists work together to make harmony. "The intellectual environment of Cambridge has provided a climate where we can delve into all aspects of the repertoire," says Professor Epstein of his orchestra. (Photo: Ed Pacheco from *Tech Talk*)

and advances in information systems are the core of a strong defense."

□ President Wiesner told the Laboratory's staff — 213 of them have been at Lincoln for 24 years or more — that it is "one of the finest examples of the synergism" through which devotion to service as well as education has strengthened M.I.T.

Lincoln Laboratory opened its doors on November 1, 1951, at the request of the Army, Navy, and Air Force to work on new techniques for protecting the country against air attack. Since then it has made pioneering contributions to radar systems, satellite communications, and information processing.

Toward a "Full Service" Health Center

The medical care given at inner-city neighborhood health centers is incomplete — even pointless — if patients fail to follow through by obtaining and using the drugs they need. That's precisely what happens all too often, even when the prescribed drugs would be provided without cost.

Nearly two years ago M.I.T.'s Urban Systems Laboratory, after a major study of medical care delivery systems for low-income inner-city residents, identified this problem and recommended that neighborhood health centers provide pharmaceuticals to go along with their medical services. Now Massachusetts regulations have been changed and a prototype Medication Delivery Service has been established by the Massachusetts College of Pharmacy at the Charles Drew Family Life Center in the Dorchester section of Boston. It's the first of its kind, and James T. King, formerly of U.S.L., says it's "one of those satisfying occasions when a research project seems to have helped convert to reality a highly desirable goal."

R.O.T.C. Breaking Enrollment Records

It's a banner year for R.O.T.C. at M.I.T.

Bucking a national trend, all three units at M.I.T. — Army, Navy, and Air Force — have enrolled the largest entering scholarship classes in their history. Everyone is pleased; R.O.T.C. is in better condition — measured by the number of its students — than at any time since 1965 . . . "an indication of acceptance toward the military by the incoming students," says Lt. Paul R. Brown, Information Officer for the Navy R.O.T.C., and especially, he thinks, a reaction to the Navy's desire to "increase its technological base."

The same idea from Major Donald T. Carlson, Information Officer for the Air Force R.O.T.C., who refers to the Air Force's "emphasis on scientific and technical excellence, and growing student interest in military service."

European Unity and World Security — a Bicentennial Lecture Series

". . .Outline policies you believe should and could be pursued by particular nations or groups of nations to increase both their individual security and the overall security of the world community during the next two decades."

Those are the instructions from M.I.T. to a series of world leaders who are speaking at the Institute this winter and spring in a special lecture series which is M.I.T.'s contribution to the U.S. Bicentennial celebration. The idea, writes the Bicentennial Lecture Series Committee, is that rates of political and social change have increased as science and technology have become more influential. "Traditional means for dealing with change" are no longer adequate, we need now to learn "to accommodate rapidly and without violence to continuing change created by man's own actions."

The series was opened by Joy Jenkins, a leading British statesman who is now President of the Commission of the European Communities, who told a Kresge Auditorium audience on December 16 that European unity as represented by the Commission is a real and potent international force; its success, he said, is of vital concern to European nations and to the U.S. Despite broad differences in languages, traditions, and systems among European nations, said Mr. Jenkins, Americans can now find — if they take the trouble to seek it — "a single European force and a single European will."

President Jerome B. Wiesner, who presented Mr. Jenkins with a commemorative gold medal designed for M.I.T. by

Classes

03

Our historic group of 1903 classmates wait enthusiastically for the arrival of each *Technology Review*. The Alumni section renews our interest in our neighboring classmates that we associated with daily in our engineering courses. However, we cannot avoid the expected and regrettable news of another cherished classmate that has finally passed on from his long and busy career. Accordingly, I have just received a letter, from his loving daughter Sallie, announcing the sudden death of her father, **Stanley A. Foster**, on October 18, 1976, while on his customary morning stroll to the store for his newspaper. He was taken to the Saint John's Hospital in Lowell where he lay in a coma for a week. The Lowell newspaper credited its distinguished citizen both as a business executive in connection with his father's prominent shoe factory, and for busy chemical engineering work after graduating from M.I.T. Stanley Foster was born in Haverhill, Mass., December 29, 1880, son of Alfred J. and Stella (Kelley) Foster. He attended the Haverhill schools and was graduated from M.I.T. in the chemical engineering course. He was long employed in the Gas Illumination section of the Consolidated Gas Co. of New York, and later at Minneapolis, Minn., and Coonigton, Ky. During World War I, he served with the Field Artillery as a Captain. In retirement Stan was a member of many community organizations and the Sons of the American Revolution. He was active in Saint Agnes Episcopal Church and is survived by a daughter, Sallie, with whom he made his home. — **John J. A. Nolan**, Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

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We are sorry to hear of the death of two classmates, reported to us by their daughters. **Alan F. Edge** of 9 Brown St., Flemington, N. J., died November 2, 1975. **Frank W. Sharman** of 1216 North Cherry Ave., Tucson, Ariz., died October 11, 1976.

Karl Kennison's wife reports that he has been operated on at the Newton-Wellesley Hospital and is now recuperating at the Wellesley Manor Nursing Home. — **Joseph W. Wattles III**, Secretary, 600 Washington St., Wellesley, Mass. 02181

09

Our class is now amongst the oldest that participate in Alumni activities. This was apparent at the last Alumni Officers Conference held last September where the name of the 1909 class secretary appeared at the top of the list of those attending. The second class listed was that of 1912, three years younger.

We regret that the 1909 class notes appear only intermittently in the *Review* because we receive so few personal items from our members. **Howard Fisher**, one of our most active members, notes on his Alumni Fund return card, "No news of interest except that I am still alive. Best regards to Art Shaw." We were pleased to hear from Howard. His address is 21 Drowne Parkway, Rumford, R.I

Harold O. Stewart, writing from Rochester, N.Y., brings back many nostalgic memories of our student days. "I have just been looking over a book of photographs taken by my old classmate **Harvey Pardee** in 1909 around Copley Square. One is of the Walker and Rogers buildings where we all had many classes. The most interesting of all were the very large engineering buildings nearly on Dartmouth St. where many of us spent many hours in laboratory work. Other pictures were of the beautiful Public Gardens; the Tug of War and the Relay race at the M.I.T. field in 1907; and a gay Christmas party in an apartment (Harold Stewart and George Palmer)."

Harold W. Paine writes from Miami, Fla., "I was surprised and pleased at your item about our long ago hockey team. I have thought that you also played on that team." (I did not play on the hockey team but my athletic activities were confined to class football and baseball and a sub on the varsity basketball team. Harold was probably thinking of my brother-in-law, the late John Dawes.) Harold's great-grandson is studying hard at prep school hoping to follow in his great-grandfather's footsteps at M.I.T.

President **Art Shaw** and Betty left right after Thanksgiving for their winter home at the Ponderosa on Longboat Key, Fla. On November 13, your secretary attained his 90th birthday. He survived four celebrations, many presents and birthday cakes, and about 80 cards and congratulations. The Class Fund is now $1,684.22 after withdrawing $50.00 to the memory of **Henry Spencer**. The interest is about $90.00 per year.

It is with the greatest sorrow that we report the death of **Henry Spencer** on October 31 at the Winchester Hospital after a long illness. He was an outstanding student at the Institute. Although his major field was mechanical engineering, he chose to select the top courses in the related fields such as civil and electrical engineering and he always attained highest grades. Thus he was closely associated with your secretary in the tough Course VI, Electrical Engineering, and we were partners in the laboratory work. For 57 years he was employed by the Blanchard Machine Co. of Cambridge whose principal product was large surface grinders used by the many machine manufacturers such as the automobile companies. At Blanchard he held the positions of general manager, treasurer and then president. He contributed much to the design and improvement of the company's product. Ever since graduation he and his wife never missed attending alumni meetings and class reunions and activities as long as his health permitted. He served on the Alumni Council and for years was Class Agent. In Winchester he was a town meeting member and served in the Finance Committee. He also was a founding member of the Conomo Yacht Club at Essex. Henry had resided at Central Green, Winchester, about a mile from your Secretary's home. He leaves his wife Madge (Hovey), three sons, Kendal H. of Manchester, N.H.; David E. of Waltham, and Richard W. of Wellesley, one daughter, Mrs. Janet Mosman of Winchester, six grandchildren and 12 great grandchildren. — **Chester L. Dawes**, Secretary, 74 Wedgemere Ave., Winchester, Mass. 01890

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Paul Tyler writes, "We can't rate 1976 as a good year. Our activities are slowing down. We escaped for a couple of weeks during an unusually hot summer by visiting Katherine's son and family in Colorado. We were entertained by several death-defying four-wheel automobile trips amid magnificent scenery, but our swimming and walks on the beach had to be curtailed."

Rock Comstock, '12

While in the east last summer, your secretary and his wife Julie stopped off to see **Rock Comstock**. He lives on the outskirts of Milford, N.H., in a 150-year-old farm house he purchased soon after retirement. Rock lost his wife some 20 years ago and has been living alone in the old house since that time. The house sits on a knoll well back from the road and is pretty well obscured by the trees and shrubs which Rock has planted over the years. Rock is quite a do-it-yourself man. He had recently purchased a ladder and was planning on painting the house, "up to a certain height," he said. He has a chain saw and cuts and splits his own wood, and has a snow plow for the winter. He has a number of interesting antiques, like a Mason & Hamlin Organ and a handsome chest of drawers. There is an old granite quarry on his property, but Rock doesn't seem to be interested in fishing.

On December 11, Clifford Loring Muzzey, '14, celebrated his 90th birthday at his house in Lexington, in which he grew up and was moved to its present location in 1913. At M.I.T. Mr. Muzzey majored in electrical engineering and after graduation he worked for General Electric until retirement in 1951. His sons, Clifford Loring Jr. and Benjamin Carver, were both M.I.T. graduates in Aeronautics and Astronautics.

A note from **Hamilton Merrill**, "Cruised for two weeks around the Black and Aegean seas under the auspices of the American Museum of Natural History. Visited Istanbul, Bulgaria, Romania, Odessa and Yalta, ruins of Troy, Sardis, Ephasus, Priene, Rhodes, Delos, Crete and the Athens Acropolis. There were five professors on board for lectures; it was most interesting." Looks like quite a trip, Ham. Maybe you'll have some slides to show us at the reunion.

I regret having to report the death of **Julius Rosenberg** on June 8, 1976 and **George Robinson** on August 3, 1976. — **Larry Cummings**, Secretary, R. R. 4, Connersville, Ind. 47331

13

In the fall of 1975, one of the New York newspapers printed a picture of **Marion Hart** and her plane with the following quotation: "At 84, Marion Hart is off on a ten-month globe-trot in her single-engine Beechcraft. She's soloed the Atlantic six to eight times (she forgets which) . . . scorns frills like radar and oxygen . . . carries nothing but a roll of Life Savers for food. "The secret of my success," she says, "is money."

We are much indebted to **Charlotte Sage** for letters and reports on Marion's ten-month trip to the Middle East. They are most interesting but rather detailed, so from time to time we'll excerpt quotations: *Calcutta, March 29, 1976:*"Went to look at Air Survey's hangar the other day and it was so dirty that I don't think I could really send my plane there. The only other place in India is outside of Bombay, but since this Calcutta place was highly recommended, maybe Bombay will be just as bad. And the only way to find out is to take a look. So tomorrow morning I am leaving for Bombay.

"If the Bombay place is the same as this one, I will just let my plane sit in its little box (not really so little — 20ft. × 8ft. × 8ft.) and send it up to Switzerland where airplane mechanics don't sit on oily floors dressed in greasy rags smeared black all over. I know that even though cleanliness is next to godliness, it doesn't necessarily produce mechanical geniuses, but it does seem one step in the right direction.

"Can't you produce a good blizzard to make me happy? Day before yesterday the temperature was 96.8° F. Yesterday 100.6°. The warm weather is approaching. Oh yes, don't let me forget: humidity 95."

Bombay, March 30, 1976: "My fortunes are changing so rapidly I can't write fast enough to keep up with them. It's like being on a roller coaster. At the moment, things are looking good, but tomorrow may be a different story. I had a bad night in Calcutta because there was no place to turn off the cold air, so I went to bed with my clothes and sweaters on, gradually unfolding until by a.m. there was nothing but my shoes. I even had to take a Valium to get to sleep, but was up for good at 4:30 a.m. However, that is all incidental. I mention it because this afternoon I fell asleep over *Newsweek*, woke up and found myself fully dressed and lying on top of the bed clothes, looked at my watch which said 4:00 o'clock and heard loud voices and laughter, looked again and it was not 4:00 but 8:00 p.m. The room telephone doesn't work and the toilet doesn't flush and the tea was cold and by the time I'd sent the toast back to become brown, it was so dried up it was like three pieces of Melba toast — one on top of the other and I was lucky my teeth were good.

"On arrival in Bombay I called Mr. Kosz—k, otherwise Joe, the Beech distributor and my last good hope on earth, who said he would pick me up. I settled down with *Newsweek*, and found I didn't have my reading glasses in my pocket, nor anywhere else. And I was to meet Joe in front of the florist. I poked the florist boy in the back, asked him to keep an eye on the baggage, and hurried over to Indian Airlines ticket office, which sent me to the far distant end of the line where a very solemn official with lots of gold braid was writing notes. 'Look,' I said, 'I just came in on Flight 273 and I had seat 4 and I just must have dropped my reading glasses there'. 'Just a minute,' said the solemn official and got up and walked away. 'Just like India!' I said to myself. 'No one ever listens when you talk,' at which moment back came the gold braided official with my glasses in hand. 'Hard Work, Industry, Patriotism, Discipline,' as Indira's placards say all over the place.

"Joe arrived in due course and I told him I hoped his hangar wasn't like Air Survey's. He took me home for lunch and then we went to the hangar, which was quite clean, and we started to discuss my problems. . . ."

In the next issue of the *Review*, we will continue with Marion Hart's fascinating trip and the difficulties she experienced. — **George Philip Capen**, Secretary Treasurer; **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd. Biddeford, Maine 04005

14

Henry Aldrich wrote in November that his grandson, David Aldrich, is a graduate student in the Department of Nuclear Engineering at M.I.T. Henry had recently flown out to Walnut Creek, Calif., for the wedding of a granddaughter who graduated from Caltech last June.

Frank Atwood has again been the guest of honor of a technical society; this time he was recognized at a meeting of the Boston Section of the Federation of Societies for Coating Technology for his 50 years of membership. Several of the national officers of the Federation came from Philadelphia for the occasion. Frank was president of the Federation in 1933, and he was a pioneer in the development of water-thinned paint, an idea that was considered sacrilegious when he proposed it about 50 years ago, but now such latex paints using water-emulsion resins constitute more than half the volume of all paints sold. Frank mentioned that his continuing activities at the hotel he owns on Martha's Vineyard enable him to meet a lot of interesting people, including Dr. and Mrs. Roman Jakobson; the former is on the staffs of M.I.T. and Harvard, and the latter teaches Russian literature at the Institute. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

I don't know whether it's this miserably cold weather here or our increasing mortality rate, but news for our column is getting scarce. To open the winter season in Florida, **Jim Tobey** is at Lake Worth (sunning in 76-degree weather — too bad), **Larry Lauders** is at Hollywood, and **Max Woythaler** leaves in December for Clearwater. Tough for the rest of us to have to stay up here. **Phil Alger** recovered sufficiently from his bout with cancer in the Mass. General Hospital here to return to Schenectady in an ambulance. (That must have been a hard ride.) He was doing well at home where in an unfortunate fall he fractured a hip and is now back in a hospital out there. We all wish Phil all the best for a complete recovery as soon as possible. **Archie Morrison** is living comfortably at a suburban nursing home here and we see him fairly regularly for lunch or a walk in the garden there.

The friendly, affable and generous **Wayne Bradley** sees me regularly when he is in Boston for a pleasant evening. His Griswold Rubber Co. in Groton, Conn., runs successfully without him, but his Moosalandee Inn in Warren, N.H., takes a lot of his time, even in the winters.

It's sad to tell you that **Ken Johnson** died November 24 in Providence, after a long illness. When he was active in business, Ken was Chief Engineer for one of the large textile companies here and did a lot to help me in our business with them.

The sympathy of the class goes to **Charlie Norton** whose wife, Bee, died December 7. Bee was very much interested in our class and attended all our class parties.

Write when you can — we'll all be glad and

interested to know how you are and what you are doing. — **Azel Mack**, Secretary, Apt. 26A, 100 Memorial Dr., Cambridge, Mass. 02142

16

Frank "Buck" Bucknam helps us to open this column with these comments: "Many thanks for the photograph and names of those attending our 60th Reunion. The classmates I remember have changed considerably since the 50th Reunion. Some have put on weight, while I, by changing my eating habits, have lost weight (20 lbs.) and dropped my blood pressure from 140 to 125. At my complete physical everything was O.K., and the doctor said I might as well keep on smoking two packages of Lucky Strikes a day — it would not hurt me at my age — 83 next month."

Joel Connolly appears regularly at public functions or before Senior Citizens groups to show slides of countries others simply dream of visiting. There is constant demand, and he travels extensively showing his slides, which he has accumulated in five trips around the world. Joel began making photographic records of his travels in 1914 and has maintained a diary since his early adult years that help in his lectures. There are three other senior citizens in his locale who are also doing this. A common problem that the four men have is trying to keep their slides catalogued. Joes said that he will finish that task "When I retire."

Paul Page Austin wrote: "I am still at Arthur G. McKee and Co., in San Mateo. Due to the low ebb of business I have taken a leave of absence until the first of the year, or until business picks up again." . . . From **Nat Warshaw**: "This is a belated thank you for the wonderful time my son, Stanley, '44, and I had at the Reunion; also congratulations on your review of the affair in the recent *Technology Review*. I finally got settled in my new home in Needham and hope to get together soon with some of our local 1916 classmates."

This happy note from **Francis Stern**: "After a lens transplant for a cataract on May 20, followed by an infection resulting in total blindness in one eye, six months of treatment have restored 20-30 vision. The class of '16 never admits defeat. I'm leaving for five months in Palm Springs, Calif., and expect to return in time to empty out a couple of trout streams." . . . Brief and to the point from **Howard Evans**: "Quietly retired, in peace and comfort". . . . **Ken Dean** wrote, in part: "I am sorry Ada and I have not been able to see you at the Reunions on the Cape. It always seems so far away and our infirmaties, especially mine, make it a bit too much of an effort."

We were pleased to receive birthday greetings from Virginia and **Joel Connolly**, and from Marjorie and **Don Webster** with the comment, "1916 seems a long time ago." And from Gladys and **John Fairfield** who noted; "No news from us, older and more tottery (alas). But a visit to a hospital quickly convinces us we're better off than lots of others, making us more smug than ever. All set for winter?" . . . Also received early Christmas greetings from **Shatswell Ober** and Sylvia and **Vert Young**. . . . **Val Ellicott** expressed his disappointment at not getting to our 60th — "I did try hard to make it. I am mailing you a copy of *Genetic Babies* to prove that I am not too old to put out a book." Excerpts from the inside back cover of the book: "Trained in medicine and public health at Johns Hopkins, Dr. Ellicott was in the front line of service when public welfare and social security came into being; and he was on the scene long enough to see the effects of these innovations on succeeding generations in the middle and lower segments of the American people. Dr. Ellicott came to the conclusion that heredity is the most important factor in human health and that man's future will depend on whether he will do anything to improve his genetic quality . From this viewpoint he developed his concept of *Genetic Babies*. Dr. Ellicott and his wife live in a suburb of Baltimore. They have three children and eight grandchildren."

We deeply regret the untimely and unexpected passing of our beloved secretary, **Harold Dodge**, on December 10, 1976. Harold was world-renowned and respected for his unique skill in quality control and statistical analysis. To each of us he was a good friend and classmate who for so many years provided the "glue" that has held us all together. He was our Class Secretary for the past 25 years and before that was our Assistant Secretary. For at least 40 years he kept us communicating to each other through him and his great Class Column. This provided the foundation on which we built good attendances at our annual reunions for the past 25 years and record-breaking attendances at our 50th, 55th, and 60th Reunions. That same personal contact by and through him gave added impetus to Class participation in Alumni Fund Drives and peaked with the then record-breaking gift by our Class on its 50th Reunion. He was a quiet man whose powers of persuasion flowed from his obvious capabilities, his personal commitment and untiring efforts, his sincerity of purpose and his purity of thought and example. We in 1916 are extremely grateful for what he did for us. M.I.T. has to be aware of how often and how well he served the Institute. He truly deserves the accolade "Well Done, Good and Faithful Servant!"

Keep your letters coming. Conserve energy, preserve your health, and we look forward to seeing you at our 61st Reunion in June. — **Ralph A. Fletcher**, Acting Secretary, West Chelmsford, Mass. 01863

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A special event is planned for our 60th Reunion lead-off luncheon. The contributions by the wives of our M.I.T. presidents are significant, though, for the most part, unrecognized. We are fortunate in hosting five ladies who, too, have served M.I.T. well. At our luncheon at Endicott House on June 9, we anticipate the presence of Mrs. Karl (Margaret) Compton, Mrs. James (Liz) Killian, Mrs. Julius (Kay) Stratton, Mrs. Howard (Betty) Johnson, and Mrs. Jerome (Laya) Wiesner. This ocassion alone should warrent a large attendance. **Tubby Strout** will be advising you of the plans and rates for our time at Chatham Bars Inn. **Ray Stevens** has consented to replace your secretary as a class co-agent to serve with **Bill Hunter**. Ray continues as Class Estate Secretary.

On a Monday noon in early December **John Lunn**, **Stan Dunning**, **Ed Payne**, **Ray Maeder** and **Jess Rogers** lunched with Hugh Darden, Institute Secretary, and Bob Blake of the Alumni Assoc., hosted by **Ray Stevens**. Various aspects of the alumni funding program were discussed, with emphasis on the need for reconsideration of estate and gift plans because of recent tax law changes. Hugh Darden gave a brief picture of the Institute financing program. In the belief that this portion of Hugh's talk would interest all classmates we asked if he would speak to us briefly at some opportune time at our 60th in June. We six found the mere getting together so enjoyable that we planned to arrange other luncheon meetings occasionally for those in the Boston area without the need for any set program or talk.

Doris and **Bill Hunter** came to town for the November alumni council meeting. On the way home they stopped in Wellesley at the **Dunhams** where they were joined by **Jim Flaherty** and **Jess Rogers** for one of Edna's good luncheons.

A news item of Northfield Inn going into receivership indicates its further availability as doubtful.

Here are names of those who returned cards in connection with last fall's 59th Reunion, several signifying their intent to be at next June's 60th: **Sam Creighton**, **Merrill Lee**, **Leon Westbrook**, **Hobart Stebbins**, **Noah Gokey**, **Ed Sewall**, **Richard Martin**, **Chester Allen**, **Helen Bell**, **Elmer Joslin**, **Jim Flaherty**, **Roland Eaton**, **Ed Sampson**, **Burling Wells**, **Earl Lewis**, **Hubert Collins**, **Rene Pouchain**, **Enos Curtin** and **Lucas Schoonmaker** who, unfortunately, has been in a nursing home for some time. It was good to have all of these cards.

Regretfully the death of **Hamilton L. Wood** at Manchester, Mass., on December 10 is recorded. — **Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

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Our second session of Continuing Adult Education took place on December 13 with Professor Robert Hollister of the M.I.T. Department of Urban Studies and Planning leading the group. He traced the development of Boston historically and topographically, and projected the future of this city by studying the past. He stated the most stable areas of the community are located in its higher elevations. These younger M.I.T. faculty are not only teaching undergraduates, but are making M.I.T. contributions to the towns and cities by working with public officials on their daily problems. It is an eye-opener to older alumni to learn how involved M.I.T. is in studying social ills of the metropolitan areas along with the traditional teaching and research programs of engineering and science.

This holiday season has been particularly happy for me in the greetings from many of you, including **Herb Goldsmith**, Frances and **Pete Harrall**, **Herb Larner**, Jean and **Mal Baber**, and Eleanor and **John Kilduff**. Marie and **George Sackett** are leaving for Florida to stay until April. **Edgar Goldstine** wrote he is about to retire, and plans to travel soon to Florida, New York, and Chicago. Ariva and **Jorge Pena-Polo** hope to come to Boston shortly and are looking forward to our 60th in 1978. Rhoda and **Charlie Tavener** spent five weeks in Alaska and the Canadian lakes. Mildred and **Charlie Watt** go south for golf in February. **Jim Flint** had a busy summer in Montana, and is getting ready for his tenth trip to New Zealand and Australia where he will do a bit of fly fishing. **Bill Wyer** reports he is pretty well but not very mobile. **Bob Rowe**'s Christmas card was most intriguing — using letters arranged to depict christmas trees and messages. Seasons greetings from Dorothy and **Granny Smith** describes their travels from Florida to New Brunswick and back visiting family and friends. He reports a serious heart attack earlier this fall, but he is recuperating. During this time Dorothy fell in the bathtub and broke two ribs. They both expect to be well enough to enjoy the holiday festivities.

Bob Gidley writes, "Not much news. I hear from **Herb Hatch** and Leon Keach,'17, now and then; also **Palmer Giles** who lives in Texas about 300 miles farther south. We have three great-grandchildren. Am in good shape for my age — 84 coming up in January."

It was good to hear from **George Woodruff**: "It has been a long time since 1918 and many things have happened. I celebrated my 81st birthday last August. Retired in 1959 after selling the cotton machinery business I had been in since 1926. I am now listed as Trustee Emeritus by several educational institutions, including Emory University. I am still serving as an active Director and member of the Finance Committee of The Coca-Cola Co. which, as you know, is headquartered here in Atlanta. My brother and I are the only surviving members of my family. He celebrated his 87th birthday on December 6, and lives here in Atlanta. We both live quiet lives, ask no publicity, and thank the Good Lord for all his many blessings."

I regret to report the deaths of **Wendell P. Monroe** in March, 1976; **Walter S. Frazier** on April 30, 1976; and **John Gustaveson** on October 29, 1976. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

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Horace W. Denison writes from Boston, "Trying hard not to grow old." **Chuck Drew** from Minneapolis says, "I am hoping to see **Gene Smoley** in Florida this winter. Greetings to **Don Way**."

Rogers B. Johnson from 704 Fair Winds, Nakomis, Fla. 33555 writes, "My wife (Wellesley '22) and I live here one half of the year and in Franklin, N.H., the other half. We are still New Hampshire citizens. My son is an executive with Dow Chemical in Midland, Mich. Two of his daughters are in Wellesley, one son in Colorado State University, and the fourth son is not ready for college as yet. I go to M.I.T. for meetings."

George Kahn, 6 Cummings Rd., Brookline, Mass., writes, "From M.I.T. I went to Harvard Medical School. Then practiced pediatrics for 30 years. I got M.P.H. from Harvard School of Public Health in 1940, and later went over to Public Health in 1954 as Director of Disease Control for the City of Boston, then Director of Child Health, Town of Brookline in 1962. Retired as consultant for Brookline in 1974. Still play tennis and squash four to five times a week. Am in good condition for the condition I'm in."

A note from **W. Roy Mackay**'s brother, Arthur J. Mackay, from SouthHill, Va.: "Sorry to have to advise you my brother died April 12, 1976."

Elliot D. May, from Winchendon, Mass., writes, "Have been confined to bed for a year now. Bad case of hardening of the arteries. My wife cares for me. Have one daughter and one son. My daughter has two sons and my son has two daughters. Son David lives in North Carolina. The business in Winchendon was bought by Newman Machine of Greensboro, N.C., in 1955. I was down there 17 years until I retired. Am living back in Winchendon now since July, 1972. Had a bad heart attack in January, 1973."

Ed Moody writes from Nashua, N.H., "News is sort of scarce up here in New Hampshire. I don't get around too much, being content to sit and read, though I do head north now and then to visit my daughter. My own family all live near here and drop in almost daily — five grandchildren plus my son and his wife. So I am not too lonesome. One granddaughter just fresh out of U.N.H. is now living here with me till at least the turn of the year, so I get my meals cooked and my bed made regularly. I do manage to get to Concord, Mass., or Cambridge monthly to attend the Traditional Contra Dances, but at this age I limit my activity to few social pleasures. Fully retired from business."

James R. Moore, 10 Oak Cir., Farmington, Charlottesville, Va. 22901 writes, "Thanks for your card. At the ripe old age of 81, we have a lovely home plus five acres for sale and we are headed for a retirement home. One can get no hired help in the South today, not even help to mow the lawn. My regards to all." . . . News of **William R. Osgood** from his niece, Dorothy A. Osgood, Chevy Chase, Md., says, "William R. Osgood is in a nursing home and is now unable to write; also he is virtually unable to read. He has lost the sight of one eye and failed considerably."

Carl W. Phelps, 681 Leyden Ln., Claremont, Calif. 91711 writes, "Your greeting for our M.I.T. Class of 1919 just received and appreciated. My service experience has been in Mission Service in Ceylon and South India, rather than the United States. My wife Mary Moulton Phelps died in India in 1949, and my second wife Jennie Erickson Phelps died in Tucson, Ariz., in 1965. I am now in retirement in Claremont, Calif., in a retirement center of some 300, some 30 or more being long-time friends. My service years with Mary were spent in foreign missions service in Jaffna, Ceylon, 1921 to 1932, and as principal of Kodaikanal School in Kodaikanal, S. India, 1932 to 1958, a school largely children of missionaries."

Lansing Mott Quick writes, "Since retiring in 1964 we have done some traveling, west coast of South America, Mediterranean (as far as Israel), Caribbean — all by freighter, the only way to travel. Also some of U.S., Mexico, British Isles, part of Western Europe. Guess my trip around the world as business manager for Frank Buck's 'Wild Cargo' in the early 1940s gave me itchy feet. At age of three score and 20, our future meanderings depend on an O.K. from doctor and banker. Happy Holidays."

John L. Riegel, 555 W. Hartsdale Ave., Hartsdale, N.Y. 10530 writes, "Margaret and I have been well, although her eyes prevent her reading and writing. That helps to keep me more than busy inside and out. Gardening and our poodle give me all the exercise I need, and I continue to save golf for my old age. Home is the best place for us. Travel is out of the question. We enjoy visits from our children, grandchildren and great-grandchildren. I am still deeply interested in M.I.T. and get there for part of a day a couple of times a year."

Edward E. Saunders writes, "Marie and I live in McLean, Va., at Carl Vinson Hall built and managed by Navy Marine Corps, Coast Guard Foundation. Eligibility for residency (250 here now) requires military service connections. We celebrated our 54th wedding anniversary last October 4 which was also my 80th birthday. Our yearly schedule includes Christmas with one daughter in Columbia, S.C., New Year's with another at Jacksonville, then six weeks at Perry's Oceanside at Daytona Beach, and a month at Sanibel Island. Also a three-week escape from the Washington heat in August to visit our son, a retired Navy captain, in Oakland, Calif. He is now an assistant vice president of the University of California handling public works at its many locations. We are both well."

Frederick C. Spooner of Lincoln, Mass., writes, "Fortunately, Mrs. Spooner and I are having good health. My interests have boiled down to developing summer homes on Diamond Island in Lake Winnipesaukee, N.H. We have four M.I.T. families living there and certainly have some most enjoyable times." . . . **Arnold B. Staubach** writes, "In 1963 I retired form the Texas Highway Dept. in Austin. From 1965 to 1970 I was connected with Lockwood, Andrews and Newman, Consulting Engineers in Houston. I am now completely retired and living at 2660 Marilee Ln., A19, Houston, Tex. 77057."

John Stevens, of Oshkosh, Wisc., writes, "All is well here and I will soon be in your area for the winter. Hope to see you in Delray. My activities continue on a rather restricted basis, but since I turned 80, I really think I feel better and *younger*. See you at our 60th."

We have all received **Don Way**'s Alumni Fund letter and I hope you have all taken care of that matter. Your secretary wishes you all the best in 1977. — **Eugene R. Smoley**, Secretary, 50 East Rd., Apt. 11E, Delray Beach, Fla. 33444

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Buzz Burroughs, the squire of Topsfield, Mass., made a special trip to New York in December to attend a meeting of the Corinthians in honor of our classmate, **Tony Anable** — the last remaining charter member of this august body of noted yachtsmen. A large number were present at the New York Yacht Club to pay tribute to Tony who is no doubt the premier navigation expert and yachtsman of this country. After active service in the U.S. Navy as an Ensign during World War I, Tony once again served his country in World War II becoming a Commander of the U.S. Naval Reserve. He was awarded the Bronze Star Medal for distinguished service in the western Pacific area. He originated the Anable Artifical Horizon, a navigational instrument and has been for many years an instructor in navigation at associations of yachtsmen and naval and coast guard officers in New York. His name appear on close to 100 technical articles on this and a variety of other subjects including chemical, metallurgical and sanitary engineering. Tony participated in a number of important sailing races to Bermuda, the Virgin Islands and Lunenberg, Nova Scotia. As an undergraduate, Tony was a track star and we have vivid recollections of his winning his "T" and a medal for the 220-yard dash. He was a speedster then and has continued through life at the same illustrious pace. We can all be proud of him.

At the meeting, Buzz ran into another M.I.T. man who mentioned that the president of his company, Hydrotechnic Corp. of New York City, was none other than our classmate **Ross Nebolsine**. We were pleased to hear that Ross continues fully active as head of the company.

I am indebted to Josh Crosby, '21, for informing me of the death of **Clyde Hall** of 728 N. Casey Key Rd., Osprey, Fla., on November 4. Clyde had spent most of his life in the Florida real estate business. He was past president of the M.I.T. Club of Southwest Florida, and he and Lucille hosted the Club at an annual picnic on their estate in Casey Key. The Halls came up from Florida to attend our 50th and were warmly welcomed, as Clyde was one of the most popular members of our class. We shall miss him. He leaves his wife, a daughter and a grandson.

At this writing, well before Christmas, greetings have already been received from Betty and **Norrie Abbott**, Pat and **Buzz Burroughs**, Mary and **Buck Clark**, Mayhew and **Art Merriman**, and Bittie and **Dick Gee**. It was also most pleasing to hear from Margaret Brown and from Vera Howes who told of a visit while in France with Denise and **K. B. White** at their interesting chateau near Paris. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

Here's another month when I don't have much class news; that makes an easy assignment for me, but I prefer it otherwise.

Ralph (Rufe) Shaw has brought me up to date on the damage to his house wrought by vandals who broke in and set it on fire while he and Madeline were attending our 55th Reunion last June. "Our living room, my study and our bedroom were totally destroyed. I lost a Steinway grand piano, a Wurlitzer organ, a color TV set, my slide library and other possessions valuable only to me. We are rebuilding our house and living in a house loaned to us by a friend. Madeline is a tower of strength in our misfortune. We are well and busy."

Ruth and **Irving Jakobson** have signed up for another M.I.T. Quarter Century Club trip, this time to Egypt. Jake sent me a recent letter from **Myer H. (Mike) Naigles** of Yonkers, N.Y. Mike writes, "After 12 years with the government in Washington before and during World War II, there followed the organization and operation of a small business — a quiet but at times interesting and exciting experience." Mike's letterhead indicates his business is the Dolphin Swimming Pool Co. of Elmsford, N.Y. The latest report sent along to the Zenitaka Corp. by **Grant Miner** included three articles from the October/November *Technology Review*: "Options for Using the Sun," "Self Reliance in China," and "U.S. Monetary Policy." Said Grant, "I found all three of them intensely interesting." The Miners spent a day early in December touring the wine country in California, visiting wineries and tasting their products. This follows the example of Helga and **Jim Parsons** two summers ago when they made a similar tour in New York state.

Alumni Fund envelopes brought in two welcome squibs. **Arnold Davis** writes that he and Cecilia celebrated their 50th wedding anniversary on June 1, 1976 at a complete surprise party arranged by their daughter Martha. All four children and seven grandchildren were present. The Davises took a trip to Maine last summer. **Ralph H. (Duke) Price** wrote, "Have lived in Austin, Texas, since retiring 18 years ago from Amoco Oil (Standard Oil of Indiana). My wife and I have enjoyed considerable travel since retirement but physical limitations (arthritis and deteriorating vision) prevent much travel now. No other health problems. Would welcome a visit from any coming our way."

We were saddened to hear of the death of **Wolfe W. (Bill) Brown** of Shaker Heights, Ohio, on November 14, 1976, Bill, a fellow Jerseyite up to about four years ago, used to attend M.I.T. Club meetings. Bill retired from Bell Telephone Laboratories in 1961 after spending his entire career there. After retirement, he traveled overseas and spent summers fishing in Michigan. Our sympathy is extended to his son Robert.

Another shocking death notice has just come in, that of **John W. Barriger III**, at his home in St. Louis, Mo., on December 9, 1976. My friendship with John Barriger goes back to 1917 when as

freshmen we both lived on the sixth floor of Runkle Hall. John's ambition even then was to be a railroad man and during his career he was the president of four railroads: the Monon, the Pittsburgh and Lake Erie, the Boston and Maine, and the Missouri-Kansas-Texas. He held a number of government posts and was a strong advocate for railroad consolidation. John and his wife Elizabeth had a 50th wedding anniversary this fall. Their children and grandchildren continued the tradition and attended M.I.T. Our deep sympathy is extended to the family. — **Sumner Hayward.** Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Shefield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

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Our 55th is shaping up real well with many couples and eight or ten singles signifying their intentions of attending at M.I.T. An encouraging number plan on going on to Spalding Inn for the extension of our short vacation. Please give all or any part of these days your serious consideration for a real fun get-together. We have just been told that pessimism is looking at the world through woes-colored glasses, but none of that will go on at the 55th. . . . **Leon S. Medalia** of Scituate, Mass., has published a book entitled *My First Ninety Years — A Doctor's Odyssey,* first printing 1976.

Martha Munzer of Mararoneck, N.Y., has worked with high school students as a resource person. They are studying the need for involving the entire community in local planning decisions. The group participated in the United Nation's Conference on Human Settlement and the Habitat Forum, which aims to have direct communication among people of many lands and to have some influence on the actions which are being taken at the official intergovernmental level. The site of Habitat Forum is a large tract of land at Jericho Beach on Vancouver's waterfront using five recycled seaplane hangars. And Martha joined their student group for a cross-country tour from Vancouver, B.C., back to Mararoneck. The group also enjoyed trips to Victoria with its suspension bridge and chasm of Capilano and beautiful flowered park. They also enjoyed Stanley Park in Vancouver. Martha is an author, educator, and a conservationist who formely served on the Town Conservation Committee.

Edith and **William G. Rapp** of Larchmont, N.Y., celebrated their 50th wedding anniversary with a trip to Belgium in September, and in October held a family party of 27 children, grandchildren and relatives. Bill is still working part time for a fabricator and steel erector, and still enjoys being 79. . . . **Edward J. O'Connor** of North Andover has completed a consultant contract with Allied Chemical by selling his asphalt business in New Hamsphire. His only duties are as Director of New Hamsphire Explosives of Concord and O'Connor Equipment Rental Co., both owned by his sons. He played golf at Andover Country Club and Delray Beach Club with a handicap of ten.

Larry Washington of Palo Alto, Calif., is the oldest member of the Ames staff as an aerospace engineer with N.A.S.A. He will consider work on Solar Energy when mandatory retirement hits in January, 1978. . . . **Philip M. Hastings** of Baltimore sends greetings from his retirement home. . . . **Frank Kurtz** of Delray has written of his tennis and bridge abilities. We hope to see Frank and Carlys in March and June. He compliments **Park Appel** on clarifying our Reunion status and program. . . . The **Bill Mueser**'s of Bedford Village, N.Y., are too active to adjust to retirement. Edna and Bill look forward to our summer meeting.

Hugh M. Shirey states his intentions to attend our Pops concert June 9, and certainly will be present with Barbara on Alumni Day. They will drive with us to New Hampshire and continue back to Rochester from there. Hugh plays golf at Kebo Valley in Bar Harbor, Maine, full of natural hazards. Two years ago he shot a 75 at Rochester Country Club and last year he got a 76 at Bar Harbor when he was 77. That's better than shooting your age and deserves fame and fortune.

The sympathy of our Class goes to the families of **Harry L. Pearson** of Moreland Hills, Ohio, and **Nathan H. Weed, Jr.**, of Ladys Island Beaufort, S.C. We also send our sympathy to the family of **Rupert S. Carven** of Weston, Mass., retired sales manager for the New England Division of Exxon Corp. After his retirement, Rupert served as consultant for independent oil companies and became affiliated with the Lehigh Oil Company of Newton. He is survived by his wife, Dorothy, a daughter and two sons.

Your Secretary and bosom companion will spend a few weeks in Florida before joining the usual Chamber of Commerce Tour in April. This year it includes Tokyo, Hong Kong, Singapore, Bali and Sydney. That's a long way to get around the world. Postcard greetings will arrive continually to the address below, including greetings now to classmates all. — **Whitworth Ferguson**, Secretary, 333 Ellicott St, Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

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Last month in the January, 1977 issue we reported that our 1978 55th Reunion would be held in Cambridge, that is, unless we had tremendous pressure to hold it elsewhere. So far we have heard nothing on this subject, so I gather that we will go along with the dates of June 8-11, 1978. Most of us would prefer to stay in a hotel such as the new Hyatt Regency which is almost within walking distance of the M.I.T. campus. The Boston Pops concert will be on Thursday, June 8 and Alumni Day on Friday, June 9.

Other news is scarce this month, but we do hear that **Pete Pennypacker** is busily engaged in building a skating rink which unquestionably will be enlarged and deepened to make a swimming pool for the warmer months. We also heard from Pete that **Al Pyle** made a short trip to Europe. Details we trust will soon be forthcoming.

Marge and I took a two-week TWA quickie to England and Scotland in September. We renewed old friendships that developed in the early 1960s when we spent some 19 months there. I was with the Barden Corporation's (U.S.A.) United Kingdom subsidiary as company director. We made another trip to Los Angeles for the Christmas holidays and returned via ship through the Panama Canal.

We are sorry indeed to report the death of **John W. Sands**, most lately of Hayward, Calif., on May 13, 1976. John received his B.S. with us in electrochemical engineering. Except for a tour of duty with the War Production Board in World War II, his career was with the International Nickel Company as a research engineer. He was active in the affairs of several professional societies. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn., 06488

24

On this lowest chill factor day of the winter, 10°F and 40 mph wind, my numb fingers hammer typewriter keys for the joy of Floridians. **Luis Ferre**, former Governor of Puerto Rico, in the warmth of that Commonwealth, smiles from the *New York Times* as he poses with the new Governor, Romero Barcelo, of the New Progressive Party which Luis founded.

Andre L. Malherbe writes from South Africa: "I'm still busy with experimental projects. Information on current American windmills and wind-electric generators will be appreciated."

Lloyd Westbrook passed on November 5, 1976, in Marblehead, Mass. He attended Exeter Academy, Cornell University, and earned his S.B. in Architecture. He was with Shreve, Lamb, and Harmon, New York City in 1949 and then the Architects Collaborative, Inc., Cambridge, Mass., retiring in 1967.

Albert S. Anderson lives at 303 Woodfern Circle, Anderson, S.C. 29621, and writes; "Lila and I found the railroads in Norway, Sweden, Finland, and Denmark a wonderful way to travel. But the hotel and restaurant prices — phew! Two dollars for a glass of beer and $6 for four pieces of bread. We have been here since September 15 and so far like it very much."

A letter from **Henry Rau**, Alexandria, Va., to your secretary states that he is reasonably busy in the broadcasting field and asks for names of admissions people to whom he can recommend a current applicant.

Bill Correale, **Paul Tishman**, and **Nate Schooler** attended the annual meeting of the Board of Governors of the New York M.I.T. Alumni Center Novermber 18. Paul was to meet Luis Ferre the next day at the Institute for a Council for the Arts at M.I.T. meeting. Luis succeeded Paul as President.

President **Frank Shaw** is urging members to make a "double your money" investment in the "M.I.T. Challenge 77" Fund, the modus operandi of which you have received. You have also received from **Gordon Billard**, our Estate Secretary, the erudite financial analysis of the William Barton Rogers Pool Income Fund by **Phil Blanchard** indicating your possible income increases.

Ed Moll, 55th Reunion Chairman, is formulating plans for a Class get-together on Technology Day in June. A behind-the-scenes visit to Old Sturbridge Village will re-enact the ingenuity of New England colonists. Watch for more information in the mails.

The fifth Florida M.I.T. '24 Fiesta in Ft. Lauderdale, December 8 and 9, was attended by Lorene and **Paul Cardinal**, Peg and **Pret Littlefield**, Helen and **Paul Miller**, Clare and **Gordon Harvey**, Ruth and **Curly Fletcher**, Helen and **Dick Shea**, Mary and **John Fitch**, **Al Roig** and **Rut Torres**. After a social hour a sumptuous dinner was enlivened by the famous Ice Follies. The next day all boarded the *Paddlewheel Queen* for an exciting and beautiful cruise on the Intercoastal Waterway, a fitting climax to a mini Half-Way to the 55th Reunion. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, co-secretary, 8 Pilgrim Rd., Waban, Mass. 02168

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It was a pleasure to receive a few days ago a note from **Doug Martin** enclosing a copy of the Palmer Park paper which featured an article concerned with one of Doug's activities. Doug has lived in the Palmer Park area of Detroit, Mich., since 1942. The Palmer Park Citizens Action Council, established only two years ago, publishes its paper monthly. The November, 1976, issue notes how Doug last year undertook the replanting and care of a neglected garden area which had gone to seed. Doug invested some of his own money and a lot of time transplanting over 40 flowering plants and adding 260 more until the 12-by-72-foot garden has become a floral beauty spot from early spring to late fall. He spends five to six hours weekly keeping the plot in shape. One of his weekly tasks is lugging 14 buckets of water to the garden, because of lack of water at the site. Doug came to Detroit in 1932 as a manufacturing sales representative for a line of air compressors marketed by Chrysler. Later he worked for Chrysler's bearing division rising to vice president before retirement in 1966. Within a year, however, he was back at work as a regional manager for a small bearing company but finally two years ago made retirment complete. Obviously, he believes in keeping busy.

Dean **Morrough (Mike) O'Brien**, now residing in Mexico, continues to receive honors. Last September he received Honorary Membership in the American Society of Civil Engineers, the highest honor given by the A.S.C.E. Mike was cited for "his innovative and distinguished contri-

butions to coastal engineering; he put that discipline on a quantitative rather than a qualitative basis through his personal efforts and by his leadership."

Henry Williams, now in Orlando, Fla. is reading, watching television and listening to stereo recordings because he is practically bedridden with rheumatoid arthritis.

An occasional visit to Cambridge allows me to attend an Alumni Council meeting. In November I found **Jim Howard** and **Courtney Worthington** on hand. Jim reports that returns on the Alumni Fund have been good, many classmates responding to the M.I.T. Challenge '77 by increasing their gifts this year. — **F. Leroy Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

We must share with you a mid-December day at Pigeon Cove. Upon arising the temperature is 40°F. The air is calm. We notice the garden hose still connected and take the opportunity to wash the salt spray from the kitchen windows. At breakfast Ruth calls attention to a line of gold on the tops of the clouds of the southeast horizon as the sun rises behind them. We wonder where is the "weather" that the forecasters predicted. I learn upon descending the stairs and opening the front door: that fast we are in the middle of a blizzard, but fortunately a short-lived winter squall as part of a cold front from the northwest. Since mid-morning the the temparture has been dropping, until at mid-afternoon it is 12°F. and the northwest wind gusting to 40 on our anemometer. Since we face due east, the wind is blowing out to sea and the ocean is churning wildly from a few hundred yards off shore as far as one can see. Spindrift flies from the tops of the waves. Normally the seagulls sit all day on the ledge at the entrance to Pigeon Cove harbor Today they would be blown off, so at least 300 have congregated on a patch of smooth sea in the lee of the Pigeon Cove breakwater — of course headed into the northwest wind. The sun is brilliant and the sky is clear except for the cumulus clouds that still hang over the horizon. It is a dramatic sight from behind large panes of Thermopane, and as long as the O.P.E.C. nations do not shut off our fuel supply we are not too envious of **Elton Staples**, **Chet Buckley**, **Ray Mancha**, **Maurice Ash**, **Cesar Canals**, **Dave Powers**, **Arthur Fuller**, and **Bill Millar**. However, as the list increases and the sun and temperature lower we may have second thoughts. However, as the hour approaches for lighting the fireplace in the study, pouring a little refreshment, and turning on the highfi, we think this is not bad either. Each to his own, especially if there is no choice or if we have made our choice.

This month we have asked Reunion Chairman **Don Cunningham** to contribute to the class notes, since he has had contact with many classmates before, at, and after our 50th. Don writes, "Before and following our 50th Reunion we received many communications from or about our classmates. Many were pleasant, others disturbing. **Albert Entwistle** had to cancel his reservation due to the loss of his wife. **Ben Richardson** cancelled from a hospital bed. **Gilbert Delvaille** was not up to the trip from California. **Frederick Walch** and his wife belatedly found they couldn't come from France in time to make our 50th. **William Sacuville** wrote that he wanted to come but was not able to leave Florida.

"**Gordon Spear**, who never missed reunions, died in the spring. He was a close friend of **Shantanu Kirloskar**, and Shantanu and wife returned Gordon's visit to India by attending our 40th. I still remember several conversations with knowledgeable classmate, who was written up in *Fortune*, and his wife a member of India's Congress, you can be sure those were conversations that I will always remember. I hope they will join us on our 55th. Even though Gordon won't be around to welcome them, they will have lots of other friends there.

"One of our 'Lost Sheep' — **Alexander Brown** — knew that something should be happening in 1976 and checked in with his wife just in time. You can add his address to the Directory: 110B Lowell Lane, Jamesburg, N.Y., 08831. With your help we hope to transfer more of our 'Lost Sheep' to the 'Found' list.

"Many of our classmates who can't come are with us in spirit. **Chia-Jen Chu** of Taiwan arranged for his son who was in the U.S. to forward his class dues; exporting money is difficult in many countries. **Win Russell** says he worked very closely with Chia-Jen when he was a consultant in Taiwan in the 1950s.

"Another dedicated classmate is **Juan T. Villaneuva** of the Philippines. He asked me for a bill for dues so he could have permission to contribute by meeting exchange restrictions. His thoughtfulness is all we needed. Hope he can make our 55th.

"**George Breck** of Ft. Lauderdale and Plymouth, Mass., died in Florida on May 3, 1976, of a heart attack. **Richard Plummer** died in England on May 16, 1976. **Allen Clarke**, one of our regular reunion attendees, couldn't come as his wife Henrietta had broken her hip. Hope she is well now and ready to make reservations for our 55th.

"We were pleased to have several classmate's widows join us, and others would have if prior commitments had not prevented. Mrs. Evan F. Wilson (Ruth) came from Arlington, Va., and has written that she had a 'very nice time.' She wrote to a good friend of Evan, Professor **Hang Y. Lo** ('Hi-Lo') in Taiwan, giving a good account of our reunion. Mrs. Arthur E. Larrat (Barbara) was with us and writes that the 50th was 'a really outstanding experience for me. . .' Mrs. Herbert Creedon (Catherine) was with us with her son for Technology Day but family responsibilities kept her from going to Chatham.

"Remember, our 55th will also be at Chatham Bars Inn in 1981."

In a recent telephone conversation with Class Agent **Chenery** (Pink) **Salmon**, we asked about the status of the video tape of our reunion. He replies that **Bill Meehan** "has been snowed under . . . but has not forgotten the video tape." Some editing and introductory remarks are needed, and the work is being planned.

Phone calls from **Jim Killian** and **Dave Shepard** plus letters from **Ralph Head** and **Bird Kelly** have brought the distressing news of **Ray Mancha**'s death. To quote Bird's letter, "Ray Mancha's wife called me Sunday about Ray's passing. She told me that it was very sudden while recuperating from a recent heart operation."

Ray, although nearly blind, really enjoyed our 50th Reunion and of course brought his banjo out on the beach. It will be a treasured part of our '26 collection. Ray loved '26 and we loved him. We have lost an enthusiastic and loyal classmate.

With these contributions we have used our share of space. Also if we told you what the weather has really done since we started these notes yesterday morning, homage would be necessary to all classmates who are basking in the sun. However, being stubborn, I must tell you that I am making ice cubes by placing the trays filled with water on the porch table. Please accept our challenge, you sun-lovers, to tell us how it is. And cheerio until March. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass., 01966

27

Only four months now to the 50th Reunion. You should all have received, with your Christmas mail, information about the Reunion together with a questionnaire and a letter from **Dike Arnold**. If you have put off filling out the questionnaire, don't delay any longer. The questionnaires will be duplicated and put together in a folder for everyone who submits one and, as long as the supply lasts, for anyone else who requests it. The more complete it is, the more we shall all treasure it.

A special appeal to those shy classmates who have not been keeping the Secretary up to date on their activities, and who have not filled out questionnaires for prior reunions. This is the time to drop the excess modesty and fill your classmates in on how you have been spending these past 50 years. Slim gleanings this month from the Alumni Fund envelopes; I assume everyone is busy getting ready for Christmas. **Larry Coffin** is still serving as a staff officer on board the *S.S. State of Maine* training ship of the Maine Maritime Academy. He and his ship assisted in the "Tall ship" race from Bermuda and the review in New York City for the Bicentennial. . . . **Art Buckley** still occupies part of his time substitute teaching in math and science in the secondary schools of Washington County, Md. . . . **Larry Cheney** is in good health; he retired nine years ago.

We have lost two more members of the class. **John Henry Harding** died on October 23. At the time of his death, he was town manager of Mount Desert, Maine. He was a member of the Mount Desert Island Rotary Club, the Northeast Harbor Masonic Lodge, and the Union Church of Northeast Harbor. He had previously been associated with Hayden Harding & Buchanan, Inc., in Brighton, Mass. He is survived by his wife, Gladys, of Northeast Harbor, Maine, seven children, and 20 grandchildren.

Leland G. Ruddell died on October 13. He had been living in Kansas City and had previously been with Kansas City Power & Light Co.

As this is written, in mid-December, your secretary is preparing to go to Atlanta with his wife to spend the holidays with their daughter and her family. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N. Y. 10583

28

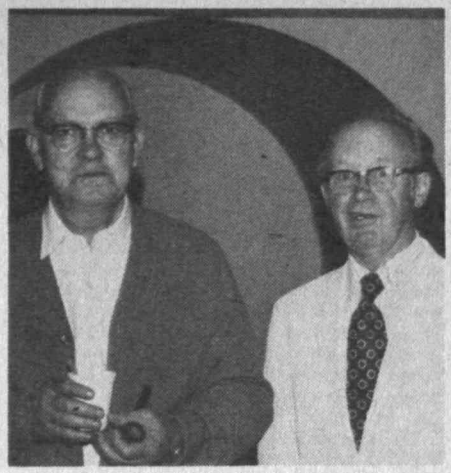
We were very much pleased to receive holiday greetings and cards from so many of you; every one of them was appreciated and well enjoyed. Verna and **Carroll Smith** made a trip to Hawaii in August to attend the wedding of their younger son Dave. Smitty and Verna still lead an active life in the Washington, D.C., area. . . . **Bill McClintic** retired at the end of last July and moved to Hot Springs, Va., although he retains his New York address. He has been busy with farm problems and still enjoys hunting. . . .Mary and **Max Parshall** have had another busy year with trips to Florida, Arizona, and Joliet, Ill., for a visit with their daughter and family. Max still gets in some fishing and Mary still does musical programs.

Newt Foster says that he and Olive went to England last April and had a car to drive for three of their five weeks' stay. . . . Lillian and **Tom Larson** left Cape Cod for the South early this year to spend six weeks in Ann Arbor, Mich., with three of their grandchildren. This allowed their daughter Linda and her husband, Dr. Behrendt, to visit medical centers in Russia on a cooperative cardiovascular research program. . . . In October Clara and **Bill Archibald** were in Australia for the dual purpose of visiting some old friends and viewing the solar eclipse on the 23rd of that month. . . . We learn that our honorary classmate, Bud Wilbur '26, has had a slight operation but that he is feeling fine again. . . . Wife Verna, reporting on **Rudy Slayter**, says she sees hardly more than his coattails as activities take him over the range from Machias, Maine, to New York City.

We are sorry to hear that **Ray Wofford** suffered a stroke last July that affected his speech. His wife Edith wrote that, with therapy, he is making good progress and that he is still able to play golf regularly. . . . From Anne and **George Palo** we have: "We are thinking of the 50th and since we seem to be writing Christmas cards about every two months, the reunion isn't very far away!" This summer the Palos spent six weeks in Britain.

The annual newsletter from Louise and **Ernie Knight** in Raymond, Maine, tells of a full and active year. The highlight was a 150-mile trip in a rented canal boat over some of the restored canal system in England. It was a leisurely two weeks of comfortable travel in a 45-foot diesel powered steel hull craft with every comfort aboard. They

John Harrison, left, and John McBrayne of the Class of '31



were delighted with the beautiful countryside and stopped at many wayside towns and pubs. In Stratford-upon-Avon they tied up for two nights and were able to attend a performance of Romeo and Juliet. Their son Paul accompanied them on part of the trip. For next year the choice is a difficult one: another freighter cruise or more canal travel. At present they favor the latter.

In a letter to **Jim Donovan**, **Bill Bendz** says that he and Marjorie plan to spend some time at Boothbay Harbor in Maine next summer and expect to see Marie and **George Chatfield** there in June. Bill has every intention of being in Cambridge for the 50th in '78.

Rest assured that plans for the 50-year class reunion are well underway. The first meeting of your planning committee was held on December 1, 1976, with 14 in attendance. A representative from the Alumni Office outlined the many on-campus services and amenities that the Institute provides for the reunioning half-century class. As details are developed you will be kept informed. For the present, however, mark you calendar and reserve the dates from Tuesday, June 6, to Sunday, June 11, 1978, for your 50th at M.I.T., and let nothing interfere!

With deep regret we report the deaths of two classmates. **Louis C. Miller** died on October 30, 1976 in Los Osos, Calif. Lou was one of the earliest graduates from the Institute's course in Aeronautical Engineering. Aircraft design and flight testing was his life work. He retired from Douglas Aircraft Co. in 1972. On behalf of the Class we extend our condolences to his two daughters and their families.

Desmond S. Shipley died at his home on October 24, 1976. Des enjoyed the reputation as the most traveled member of the class. During the war years he flew for the U.S. Air Force and was an airlines captain for American Airlines for 35 years. We have expressed sympathy of the Class to his wife Nathalie. Des also leaves three daughters. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 0l890

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Eric A. Bianchi writes, "Thank you again for the birthday greetings — this one has a special significance as I have entered into another decade and have become 70 years old. I have not noticed any change yet; I do not feel any older and I hope to keep it that way. We had a fine visit with Joan and **Wally Gale** in October. The weather was great, the foliage superb, and the hospitality on a very high level, as usual. We still have no definite plans for permanent change to Florida, but I am still interested and Kay is weakening. We shall again be in Tequental, Fla., for January and February, 1977." . . . A note from **Amasa G. Smith**: "I am looking forward to our 50th and I hope I can make it. Will try to stay active and well, as you suggest. I see **Larry Luey** quite often, as we play golf together. He is fine and doing quite well. I am still involved in United Appeal, Boy Scouts, U.M.C.A. and my church. Lately, I have put quite a bit of time in the political field, by joining others in raising much-needed funds for President Ford and the Republican Party for the campaign."

Earle H. Abbe is enjoying his retirement, having an ideal situation whereby he spends six months in Nebury, N.H., and six months in Boynton Beach, Fla. He and his wife Martha like to travel. They took a trip to Alaska in 1975, and a cruise to the Caribbean, and are planning a trip to Egypt soon. They hope to join all of us for the big 50th which is on the horizon.

Mrs. Raymond G. Haun (Ruth Davies) has sent a note: "We are leaving California on December 11 for a Christmas cruise to the South Pacific and will be back in Florida in January. We are both enjoying our retirement years and feel that we are very fortunate to be able to live in two such beautiful parts of the country, Southern California and Florida. Our health is excellent, other than my arthritis which has slowed me down a bit."

Henry S. Muller writes, "We are alive but not too well. We had a good summer and good crops, except for apples, peaches, corn, and hay. We had a very dry spring and a cold, wet summer and fall. The little creatures indicate a very hard winter in the hills of Ohio." . . . **Edward B. Papenfus** writes, "I am still in very good health at age 70, enjoying my retirement, and keeping my interest in politics and world affairs. My efforts are directed in political activities, trying to arrest the drift of the western world towards socialism and communism and persuading our government (Canadian) to control inflation by stopping deficit budgeting and spending."

Frederic D. Merrill is dividing his retirment time between auditing and accounting courses at the Fairleigh Dickinson University, and activities and hobbies. . . . **Larry Moses** writes, "My wife Kay, daughter Kathy, and I attended the George Mason Reunion on June 11 and 12 at Gunston Hall to celebrate the Bicentennial of the adoption of the Virginia Bill of Rights. Both Kay and Kathy are direct descendents."

Louis F. Southerland is still active in his architectural profession, a Senior Partner in Page, Southerland, and Page, Architects and Engineers, which has a staff of over 150 professionals. The firm's main office, built recently in Austin, Texas, won a design award from the American Institute of Steel Construction. . . . **John McCaskey** and his new bride, Marian, send greetings to all '29ers; John is planning a mini-reunion of the Class of 1929 in Montana in June, 1977; Wally Gale has been designated as promoter and the director of the affair. . . . **Theodore S. Alexieff** has sent a note: "My retirement continues contendedly since 1972. Have traveled a bit to foreign shores and hope to do some more next spring."

Gus Stein writes greetings to his friends and hopes to see us in Florida this winter. . . . **Frank Mead** and his wife Mary left for their winter quarters in North Port, Fla., in the early part of December. They will be there until April. Aside from his duties as Chairman of our 50th Class Gift Committee, Frank is active in many alumni and club affairs on the West Coast. We are at the halfway mark, and you will hear from Frank about meeting our goal of a meritorius class gift in 1979. — **Karning S. Dinjian**, Secretary, 6000 N. Ocean Blvd., Apt. 14-E, Fort Lauderdale, Fla. 33308

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The returns this month are rather lean — only four brief items and all from retires. **Mark Culbreath** retired from Burns & McDonald Engineering Co. in Kansas City at the beginning of 1969. He reports that last May he was slowed down a bit by having a kidney removed, but has made a good recovery and is now nearly back to normal. His current activities include spending considerable time "studying the *Wall Street Journal* and other financial publications to improve my investments." Over the last five years that project must have required some pretty intensive study, Mark. . . . **Willard Morain** also retired in 1969 but has been consulting on and off. Since 1974 he has been back working for his former employer, Cooper Energy Services, as a consultant and "enjoys the opportunity."

Elmer (Al) Burling retired a number of years ago from his job as executive vice president of Improved Machinery Inc. of Nashua, N. H. He now uses up considerable time in opening, closing and trying to maintain the Burlings' homes in New Hampshire, Cape Cod and Florida. Regular reunion attenders will remember the Burlings' daughter Lorinda who is now married and has three children. The Burlings from time to time see Cynthia and **Bob Reynolds** who also have a home on Cape Cod. . . . **Riagio A. Carideo** has retired from his job as development engineer at the Army Research and Development Laboratories in Natick, Mass. He also lives in Natick now, and spends his time on home projects, reading and travel. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N. Y. 10036

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A Christmas card from Charlotte and **Ed Hubbard** tells of a "fabulous" trip to the island of Mallorca with Dorothy and **Dave Buchanan** on an M.I.T. Quarter Century tour in October. Dave's note confirms that it was a great trip. Dave also reports that he was president of the local country club in Peterborough, N.H., for the past year and also Chairman of the Executive Committee of the Union Congregational Church. Dave seems to be adjusting to retirement without any trouble.

A news release reports that **William P. Kimball**, Professor Emeritus of Civil Engineering at Dartmouth College, received the Linton E. Grinter Award for outstanding service in Philadelphia in October. . . . **Ed Ducayet** writes that he enjoyed his first reunion (the 45th) and is looking forward to the 50th. Ed's address is 3471 Sagecrest Terr., Fort Worth, Tex. 76109. . . . Congratulations to **Ken Germeshausen**, who received an honorary Doctor of Science degree from Franklin Pierce College.

A note from the **Jack Lanes** reports that they didn't make the 45th Reunion due to Bert's illness. I know all of us are sorry to hear this and wish Bert the best of luck for a rapid recovery. Jack, now retired, keeps busier than ever with his consulting work for C & R . . . but unfortunately Bert couldn't join him in Paris this past year for health reasons. . . . Judging from the news, **Emile Grenier** seems to be winning his fight with Congress to postpone action on the so-called safety bags in cars. Good work, Emile! A Christmas letter from him tells of his trip over the eastern and southern part of the U.S.A. and into Canada to see some of his relatives early last year. During the trip, they attended an International Dental Research Meeting in Miami where his wife, Ella, gave a paper titled "Microcapsules on Streptococcus Mutans Serotypes by Electron Microscopy." I am sure that it would have been way over my head.

Thank goodness no deaths have been reported since our last notes. Hope you all have a wonderful 1977. — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, Fla. 32757; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, Mass. 02158; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216

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Your 45th Reunion Committee under the expert guidance of **Don Whiston** and **Bunny Nealand** held its first meeting on November 18, 1976 and established assignments for our activities on June 9-11, 1977. By the time you are reading these notes I trust you will have completed your reunion questionnaire and returned it to Bunny Nealand. I am sure you can appreciate its importance for planning purposes, so please don't delay in responding. . . . Incidently, Bunny has become the busiest man on Cape Cod since his retirement from the Institute. Like all us active retirees, he is wondering how he ever found time to work, with being: chairman of our Reunion Committee, trustee of his Church, trustee of the Library Memorial Fund, on the Board of Directors of a newly formed Cape Cod M.I.T. Club, consulting, town activities, and relaxing with yard work and fishing. Besides Don and myself, he has reunion responses from **Don Brookfield**, **George Kerisher**, **John Finnerty**, **John Brown**, **Bill Pearce**, **Bob Minot**, **Mike Castleman**, **Rolf Eliassen**, **Winston B. Braxton**, **Benjamin R. Chadwick**, **Rolf Morral**, and **Lawrence F. Wagner**. Let us all continue to keep Bunny and Eleanor busy with those responses, and then as he so aptly put it, they can begin to think about ways to retire from being retired.

I am writing these notes in early December and have just received our first Christmas note from **Juan Serralach**'s wife Suzanne. They are both fine, but will not be with us in Washington this season. We hope they will be with us for the reunion. . . . A pleasant note from **Fred W. Green** related "a saga of a proud Mama and Papa." Their 23-year old daughter graduated from Stoneleigh Burnham in 1970 and entered Boston University somewhat against her will. Quit at Christmas time. Took up tennis and played around the Boston and New York area. After six months of this she wanted to devote full time to tennis. This she started to do with her mother's backing. Last circuit she was on was the Missouri Valley. Also on this circuit was a recruiter from the University of Maryland. Through many road blocks, she, with the help of the recruiter is back as a freshman in college and doing well in her studies and tennis.

Albert W. Dunning is still actively engaged as President of Dunning Associates, Longmeadow, Mass., specialists in electrostatic powder and industrial coating processes. . . . **James D. Abbott** retired from the Gillette Company, October 31, 1976. . . . **Arthur L. MacKusick** reports that he and Bettie enjoyed visiting Helen and **Phil Benjamin** in Lakeland, Fla., last February; and were also guests of Fran and **Newt Newton** at the M.I.T. picnic, Casey Key, Fla., in April, 1976. . . . **Alva T. Wilson** sold his little package store in Marshfield, Mass., last May and has joined the ranks of the retired. Currently, he is recovering from major arterial graft surgery which he hopes will improve the circulation in his lower back and legs.

John C. Lyon, in a very interesting note, wrote that he will be at our 45th Reunion. After nearly 42 years with the Budd Company, Railway Division, Philadelphia, Penn., he retired August 1, 1975. John maintains very active interests in sailing, which started as a hobby back in 1932 with his friend Dick Ashenden '31. The Lyons and the Ashendens have cruised annually since 1960, and when John acquired a 32-foot sloop in 1968, they began trading sailing weeks with each other — New England in the summer and Chesapeake Bay in the fall. John was one of the first recipients of a Sloan Foundation Fellowship during 1937-38. He was the first winner of the Waldo O. Ross Trophy for winning the Second Summer Race series in 1937. He had a pleasant reunion with Dick Morse '33 on his yawl in Quisset Harbor during 1975. In addition to his sailing John stays busy with the U.S. Power Squadron's educational program, and since retirement contributes one day a week as a volunteer instructor at the Franklin Institute.

It is with deep regret that I report the passing of **Irving Schell** on July 27, 1976 and **Charles O. Perpall** on August 31, 1976. The sympathy of the class is extended to their respective wives and families — **John W. Flatley**, Secretary, Apt. 204, 5100 Dorset Ave., Chevy Chase, Md. 20015

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Top billing this time isn't easy to choose; so we dedicate this one to all of the faithful whose names appear below. **Joel Stevens** writes that soon after the M.I.T. Fiesta they took off for Costa del Sol. No question about Joel's becoming a Fiesta addict. . . . Leoba and I were pleased to receive a short message from **Jim Turner** to do with our troubles, now most fortunately a memory. Jim and Edna send their best to all of you.

Bill Baur and Clare spent the summer at Gloucester, feasting on clams and fish. They had many visits from children and grandchildren, and enjoyed returning them. Now for the real surprise: the Baurys were special guests at their own 50th wedding anniversary celebration held at the Town Line House in Lynnfield. Later they spent a week in western Canada sightseeing, and visiting friends in and near Calgary. On their return, Bill attended the fall dinner meeting of the Central Florida M.I.T. Club, of which he is Secretary-Treasurer. Guest speaker was Warren Seamans, Director of the M.I.T. Historical Collection. Apparently, the Club has come back to life, as it naturally would with a stem-winder like old Bill taking hold.

We had a most pleasant surprise in early December, when a phone call came from **Guido** (Garby) **Garbarino** and Mary. Apparently, they had just found out that Leona had been ill, and hastened to verify it. Garby is retired, but like many, is consulting, both for Westinghouse, and several others. Garby must be an expert on Poland and Mittell Europa.

Jean and **Cal Mohr** write that they are retired and living in Ohio. Cal included a couple of clips about the passing of John Petrossi, '31, whose escapades were noteworthy for those of us who lived in the "new dorms." . . . A press clipping informs us that **Herb Grier** has been retired as of last April. Herb might be called "Mr. Nuclear Energy" since he has been associated with that field for over 40 years, beginning with the original Manhatten District Project. Herb was one of the original partners of EG&G (Edgerton, Grier and Germeshauser) with whom Herb worked while studying for his Master's, and afterward. Herb's story is about as romantic as one might imagine; his classmates are very proud.

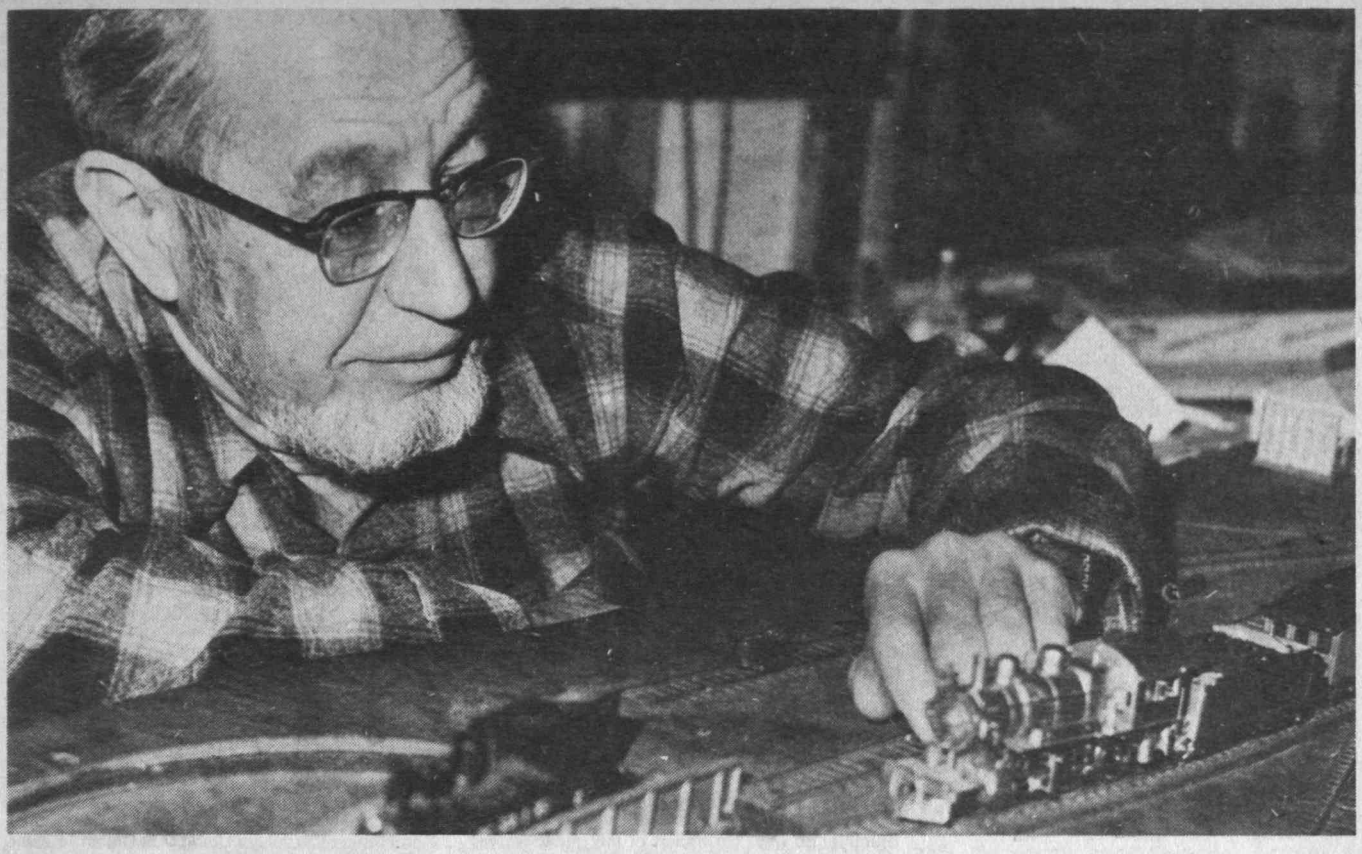
A press realease from Raytheon informs us that **Bob McCormack** expects to retire from the job as Vice President of Manufacturing at year-end. Bob joined Raytheon in 1938, which makes him close to a 40-year man. . . . **Newt Buerger**, formerly Professor at the Naval Post Graduate School at Monterey, Calif., writes of several moves since last heard from. Newt had a chance to be Chief Metallurgist for Viking Metallurgical Corp. at Verdi, Nev., in 1967, so he sold his Pebble Beach house, and bought a condominium at Tahoe. Then he bought a house on the golf course at Mission Viejo, Calif., and moved there, though still with Viking as a consultant. Daughter Brenda lives nearby, and is married to a Continental pilot. Son Chip used to live nearby, but, being with I.B.M., managed to be transferred to Cedar Rapids as Marketing Manager. Newt says he is enjoying retirement.

After several years, we have a note from **Tom FitzPatrick**. At last word, he was about to take a boat trip around the world. He did make a start, and went to New Zealand, then to Australia, where he spent a month in Melbourne; he returned via air to Singapore, Kuala Lumpur, Bangkok, New Delhi, Cairo, London, and Oslo (for Christmas), thence home. Found India discouraging, and Cairo an armed camp, but did enjoy Malaysia and Thailand very much. Last year the travelers spent the winter in Cassis, a small village on the coast near Marseille. As a summer resident of Highlands, N.C., Tom is really an engineer, as he discusses septic tanks and drainage fields, et al. Son Bill is in Colorado, fighting the weather and cattle prices; Pete is busy running his home for boys, and is part-time Rector of the Episcopal Church in Scottsville, Va.; Kevin is a director-producer for Cox Broadcasting in Charlotte, N. C. Tom and Beverley have purchased a new home on an island with a view of boat traffic of the Inland Waterway, 30 minutes from downtown Savannah. In March comes another boat trip: first to San Francisco, then through the Panama Canal, around South America, to Buenos Aries, and home by air.

Dick Faldetta retired from N.A.S.A. Lewis Research Center in Cleveland in July, 1973. He is not at all active, avoiding all projects, and does a lot of tennis playing. Also, he is in investments, though how is not clear, and he is Adjutant of his American Legion Post. Dick has no interest in traveling, so he sends his wife, Mary Kay, in his stead, with a local girl friend as companion. She has been to Europe twice recently. Mary Kay also is active in Red Cross work. Daughter Richele has just received her Master's in Theater and is currently in New York looking for a position in commercial acting. Daughter Jane spent two years teaching high school in Australia, but is back and busy trying to find a simliar teaching spot here. She expects to marry come June. Son Steven, works at N.A.S.A. and is married (early this year). Younger son Neal, 20, has started his own business, in appliance repairs. Dick mentions that he met Mary Kay on a tennis court in Arlington, Mass., so they are from my hometown, though I have not lived there since before World War I.

Ruth and **Bob Timbie** sent Christmas greetings. Bob finally made his first visit to central Florida, long planned. September found the Timbies in Belgium, visiting their daughter, Judy, and four grandchildren, all teenagers. After the family visit, the Timbies toured Belgium, Holland, Germany, Luxemborg, France, and England.

Charalee and **Dick Fossett** sent us a fine card and a special message (special because it was so cordial). Dick inquired about my farm project (water supply). I was only the engineer; a backhoe and a dozer did the work. I bought 950 ft. of 2 in. plastic pipe, and we used all but 11 ft. Another project was a connection to a pressure sewer. I was again the engineer: no hardship. It appears that the Fossetts did a lot of skiing last winter, but have not been too active since then because of family illnesses. Dick's mother had a heart attack in June, and they visited with her in Boston until her recovery. She is fine now. Then Charalee's sister in Oklahoma passed away in the summer, after a protracted illness, and the Fossetts were with her over quite a long period; as one might expect, Southwest summers are really hot. They leave soon for a Caribbean cruise on a Cunard ship, which appears to have plenty of merit. Dick say that he can't attend the 44th, but



Retirement . . . a time to do everything you've always wanted to do. Robert Franklin, '34, is so busy now that he still hasn't the time to build the model railroad he'd like. (photo: Charles R. Koehler)

Limits to Retirement:
"I'm Just Getting Too Involved"

Robert M. Franklin, Secretary of the Class of '34, has kept busy in retirement, almost too busy. The following is an excerpt of an article by Charles R. Koehler reprinted from the Cape Cod Times.

Robert M. Franklin, of Setucket Road, Brewster, loved Cape Cod, retired there — and then got so busy he is seriously considering limiting his activities. "I've got to conserve my time a bit," he says. "There are just so many hours in a day and days and nights in a week."

He is best known in Brewster as chairman of its conservation commission. But he also is treasurer of the Cape Cod Model Railroad Club, teaches sailing courses with the U.S. Power Squadron, is an amateur photographer, a bird watcher, attends gatherings at the Cape Cod Museum of Natural History, is active with his wife in affairs of the town's historical society and the Cape Genealogical Society, and counsels Cape High school students who wish to enter the Massachusetts Institute of Technology.

How does this scholarly M.I.T. engineering graduate find time for it all? "The truth is I'm just getting too involved," he laughs from a comfortable living room chair and a view overlooking Canoe Pond. "I'm so on the go that I've never had the time I want to build the model railroad layout I'd like," he said. He retired to Brewster in 1968.

Franklin graduated from M.I.T. in 1934 and his working career spans early years with a family business — he is a Philadelphia native — three years with the Carrier Corp., and the balance with Sperry Corp., 28 years in the New York area and a home on Long Island.

His interest in railroading goes back to his M.I.T. days where his degree was in electrical engineering. He returned to Philadelphia and tried to get a job with the Pennsylvania Railroad, which used electricity between New York and Washington, D.C. "They didn't have any jobs," he recalled. "Anyway, I remember thinking then that the two jobs where you had to wait for someone above you to die before getting promoted were in banking and railroading. It wasn't for me."

His enthusiasm for the world around him and his technical training and career indirectly lead to his work in conservation here. "I felt it was an area with something to do that would be interesting to me," he said. "Of course, we don't have the major problems they have in Barnstable. But there is a lot to conservation.

"People, for example should not conclude it's 'snob zoning' when we set limits on lot sizes. There is just so much sewage the ground can absorb withour water table pollution or the big expense of a municipal sewer system."

His affiliation with the U.S. Power Squadron dates from his Long Island sailing years where he owned and sailed his own sloop.

Mrs. Franklin is treasurer of the Brewster Historical Society. "Her work there and with the genealogical society tends to get me involved," he mused. Both are active with the First Unitarian Church, also.

Does he have any advice for new retirees?

"Firstly, I'd suggest they not join anything too quickly. Let a year or so go by. If you join immediately and want to resign, you create enemies. If you join too soon, you could be looked on as a 'butter-in'.

"But philosophically, I'd say in time your values and experiences become known and you are sought out in your community.

"Above all, don't tell them how it was done in Michigan, or Pennsylvania, or New Jersey, or wherever. This really turns people off. Learn their ways, their views, your community, its problems, its hopes and objectives. Then, if you're asked to pitch in, suggest ideas but don't make comparisons with other places."

will be with us at the 45th. No comment!

Dick Smith and Eileen write that they are enjoying the warmth of Key Biscayne, walking, jogging, swimming, and find it bearable in contrast with Chicago. We too are enjoying, minus the jogging, running and more. We praise the Lord for allowing us to be here.

Now for the Fund capsules: **Ferdinand Johnson**, Ferd to you, writes that he is semi-retired, whatever that is. They have just returned from a two-month tour of the Northwest, and will see us at the reunion. . . . **Forrest Dexter**, of the Maine Dexters, writes that he is still teaching environmental geology (was it University of Maine at Farmington?). I quote, "I am Staff Director of the Citizens' Committee, Dickey-Lincoln Project, Impact Review, appointed by Governor Longley to help decide if the Dickey-Lincoln dams should be built on the St. John's River."

I have a note from a fellow I knew rather well as a student, **Charles Keller, Jr.** If I recall correctly, he was a graduate of the Military Academy at West Point, but was a full-time candidate for a degree with our class. I have regretted that I lost track of him. Charles is Chairman of the Board of Trustees of Historic Faubourg Street, Mary Corp. of New Orleans. He says it's a nonprofit development corporation dedicated to renovation of historic buildings in the central business district of New Orleans. Charlie, will you drop me a line and tell me if I have the right Keller? You sign yourself as Course IV.

Reporting the passing of classmates is one of the less enjoyable chores for any class secretary, and, fortunately, we have only one to report this issue. In early November, **William H. Brown**, long time Professor of Architecture at M.I.T., passed away. Professor Brown had his own private practice, as well. On behalf of the class, we will drop a line to his nearest of kin, as apparently, his wife does not survive him.

I'm glad to have so much news from so many as I prefer many names with a short message, than three to four long ones. — **Warren J. Henderson**, Secretary, 1079 Hillsboro Beach, Pompano Beach, Fla. 33062

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We "Cape-ies" are growing numerous enough to make a start at an M.I.T. Club of Cape Cod. An organizing meeting was held on December 8 and our class was well represented. The ones I saw at the luncheon were **Herb Ausin**, **Ralph Brown**, **Russ Franklin**, and **Ray Jewett**. A pleasant surprise came when **Larry Stein** arrived; he had cooked it up with Ray on one of their Sunday "ham" talk-fests and managed to find some business that needed tending on the Cape that day. I don't think I missed any other members of the class who might have been there, but if you live down on the Cape, you will find our future meetings fun.

About all the other items I have came through the Fund notes. **John Hawkins** is getting ready to join the ranks as he writes, "A milestone coming up: retirement date is set for April 1, 1977. Plan to stay put in Hingham where I now hope to make time for sailing from the Yacht Club and golfing at our neighboring club in Cohasset. Have been working in the cement industry end of Industrial Controls at the Foxboro Co. and plan to keep an eye out for a chance to do part-time consulting."

Adolph Warsher notes, "After having been caught in the great G. M. layoff of 1973, I am now serving the FBM Program (Trident) in the Charles Stark Draper Laboratory as Reliability Staff Engineer in the Technical Assurance Division. The Draper Lab has just moved into Tech Square."

George Westefeld shows he's doing things the right way when he says he met Dorothy and **Phil Walker** on the October 24 "Fabulous Mallorca" trip with the M.I.T. Quarter Century Club. — **Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Chevy Chase, Md. 20015

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A Christmas card arrived the other day from Verna and **Gerald Rich** who are now living at 347 Massol Ave., Los Gatos, Calif. . . . **Bernie Nelson** called to see how I had made out December 5, and I was pleased to say that I am fully recovered. Bernie was elected president of the new M.I.T. Club of Cape Cod at its latest meeting, at which the Class of 1935 was well represented with **Hank King**, **Charlie Goodale**, and **Prescott Smith**. Bernie and Rhoda were leaving shortly to drive to Texas to spend Christmas with their daughter. **Bill Bates** also called and said he was flying to California to spend Christmas with his older daughter and three granddaughters in Burlingame. His younger daughter lives in Westport, Conn., with husband and son and daughter. Bill's son is single and lives in Chicago.

Bob Forster and Connie are home in Wellesley and Bob appears to have weathered the two years in Sweden with his usual aplomb. They are going to San Diego after Christmas to visit one of their sons and will be back in Wellesley as you read this.

Sam Brown's Christmas letter contained the sad news of Helen's death on November 1. Since the discovery of malignant tumors in October, 1973, she had fought the good fight, and with the aid of a two-week interval chemotherapy regimin she had as Sam says "beat all the odds." She had been given only 12 to 18 months, but doubled it for which Doreen and I were especially thankful for we had some wonderful days on the golf course with Helen and Sam. I know I speak for all of us when I offer Sam our deepest sympathy. Fortunately, he finds himself very busy, continuing as a Director and member of the Executive Committee of Brooklyn Union Gas Co. and Kaiser Steel Co., and as newsprint supply consultant and a Director of Catawba Newsprint Co. for the Newhouse Newspapers. Last June Sam completed the 70-hour initial training and started to serve a one-day shift (12 hours) each week with the Short Hills Volunteer First Aid Squad. You recall Sam retired 18 months ago from Coverdale and Colpitts of which he was Chairman.

I am also sad to report to you the sudden death of **Luke Packard** on December 5 at his Melvin Village, N.H., home. He was not only a familiar figure at the boat-house and in our Course VI classes, but my first company back in 1951 was an early vendor to Luke's Technology Instrument Corp., which later became a part of Bowmar Instrument. He moved to New Hampshire and was one of the co-founders of the Kingswood Bank and Trust Co. in Wolfeboro upon his retirement from Bowmar, for whom he was still a Director. To Mary and his three sons we send our deepest sympathy from all his former classmates.

Virginia and **John Taplin**, together with another couple, flew from L.A. to Aukland, New Zealand (a 19-hour journey) in mid-October and spent the next ten days exploring the North and South Islands including the glaciers of Mt. Cook in the New Zealand springtime, ending up at Milford Sound on the west coast facing the Tasman Sea. John's new company is CONTEXT Corp., which he started two years ago soon after retiring from Bellofram. They make automatic reading machines which John developed that can read 400 characters per second or roughly 80 words per second. The machines go for $5,000 each and demand is heavy. They are used in the printing industry for type-setting, and in teletype transmission — they eliminate the need for a key punch operator in automatic data processing, since they convert what they read into a digital code.

Before I end these notes for this issue I must say that I am excited and exhilerated by the new feeling of vitality and energy I have after this fantastic surgical procedure. I had no idea how much I had been slowed down over the years until now; I just do not get tired any more, at least not yet and I've been putting in full work days for three weeks. Today, December 14, is six weeks! — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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A note from Geneva, Switzerland, conveys the news that the **Roman Ulans** are returning to this country where they are building a home in Pipersville, Penn. (Box 189, 18947). When I looked in the Singapore telephone directory the Ulans were listed, but by that time they had moved to Geneva with Communications Satellite Corp. . . . The **Walt MacAdams** are at home at Big Indian Mountain Club, Oliverea, N.Y. 12462. . . . **Dick Denton** wrote a newsy letter while he was recuperating from gall bladder surgery. I quote: "We see **George Robinson** frequently. He retired from Bakelite several years ago and is now Township Manager for Clark Township, N.J." The Robinsons have a summer home on Martha's Vineyard and also own part of a motel in the Dutch part of St. Marten in the West Indies. Of his own situation Dick writes, "I think you know that we run a small business making high vacuum equipment and optical coatings. This keeps growing and keeps us busy. Some of our products are sold to laboratories throughout the free world. Now we seem to be getting drawn into solar energy coatings and other projects that are larger than anything we have attempted in the past, and although I guess we could sell out and retire, it doesn't seem possible to let so many new things go just as they are becoming so interesting." He goes on to say that his (and Virginia's) three children are all married and by now there should be five grandchildren. With their son Peter, Dick and Virginia share a sailing auxiliary at Newprt, R.I. They like the area and have purchased a small condominium at the "Brick Market Place" facing Newport Harbor. In closing he says, "We are certainly happy that our kids have done well, so far, but I think that the biggest measure of satisfaction with them is that they no longer call us collect!"

Dick Halloran, one of those present in Cambridge but not at the reunion at Jug End, has written from San Francisco to say how much he enjoyed and was impressed by Boston after an eight-year absence. When **Art Carota** visited the west coast Dick and Art "reuned" with Mary and **Bill Mullen**. He says, "Bill Mullen and I are both self-employed as consultants (the only way to go!). Our field is construction methods planning and construction price estimating. Bill's clients are almost entirely engineers and architects while mine are engineering construction contractors. Thus we have many a spirited discussion on the best ways to keep out of trouble on the wide range of local, national and overseas projects that we survey." Along with other Course XVII alumni, Dick regrets that M.I.T. no longer offers an organized four-year course in construction management/civil engineering. He sees a need for younger people who have had the rigourous training which used to be given. Who knows, some day the pendulum may swing back that way again. . . . Meanwhile, it's fun to receive letters, so do write. — **Alice H. Kimball,** Secretary, P.O. Box 31, West Hartland, Conn. 06091

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Robert C. Winans, S.M. '37, retired from Bell Laboratories on July 1. He plans to keep busy sailing his 27-ft. sloop and looking for a new home closer to good sailing waters. . . . **John C. Gibbs** writes that he is still Executive Vice President of the Nevada Power Co. at Las Vegas, Nev., "the only place to live." . . . **Ed Corea** is recovering from a cataract operation performed November 17, at the South Shore Hospital, Weymouth, Mass. He did consultant work for the Navy in Pomona, Calif., last year. While in California he talked with **Joe Dunning** who lives in Hollywood and works at McDonnell Aircraft. Last summer he visited his daughter and son-in-law in Koln, Germany, and while in Europe visited Amsterdam, Munchen and Heidelberg. . . . **Hjalmar D. Bruhn**, S.M. '37, is professor of Agricultural Engineering at the University of Wisconsin, Madison. He is busy teaching and designing machinery for the economic extraction of plant juice protein (now mainly alfalfa).

By the time you read this you will have received notice of plans for our 40th Reunion. We plan to start Thursday evening June 9, with cocktails and a buffet at M.I.T.'s Historical Collections Building. Buses will then take us to Symphony Hall for M.I.T. Night at Pops. Friday, June 10, husbands and wives will participate in Technology Day. That evening we will have a private reception, dinner, and dance at the Venetion Oval Rooms of the Copley Plaza Hotel, Boston. Saturday, June 11, chartered buses will take us to the Essex County Club for a day's outing of golf, tennis, swimming and visiting along with lunch and an early evening clambake. We will close our reunion at noon after brunch at Burton House. If you have not already done so, let us know your plans.

It is with deep regret that we report the death of two of our classmates. **Robert Laurence Johnson**'s wife wrote that "Laurence" died after a long illness, in April. Her address is 353 East Ave., Pt. Pleasant Beach. N.J. 08742. **J. Thomas Egan** of 47 Chestnut St., Marblehead, Mass., died April 13, 1976. — **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester M. Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148

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This month we '39ers can bask in the light of glory reflected from two classmates.

Morgan Sze's picture appears on the cover and with a two-page article in the December 6 edition of *Chemical Engineering* magazine. Morgan was awarded one of four "Personal Achievement Awards" made every second year by this prestigious magazine. Morgan is Vice President and Manager of Lummus' Engineering and Development Center and the two-page article reports his receipt of more than 50 patents and his "uncommon ability to take information from one area of technology and apply it elsewhere".

Dick Cella's New York restaurant was judged by *Forbes* to be among the *very best* of places to eat in New York. Based on our own visit to Dick's restaurant, Hilda and I have to agree with *Forbes*. As we remember some of Dick's other achievements (which include designing and maintaining airplanes and encouraging the U.S. Air Force to adopt his ideas to improve its defense posture), we'd say Dick continues to be one of our high flyers.

Jack Wood, '17, is well known for the pleasant hours he helped us enjoy with the dinghies at the sailing pavilion. During the last ten years Jack created and administered the Junior Program at the San Diego Yacht Club. Last Sunday Jack and Helen invited Hilda and me to enjoy a fun sail on their Tartan 26 sloop. Jack retains his keen interest in M.I.T. and in the many friends he made in the sailing fraternity. He would enjoy your visit or a note addressed to his home at 3639 Charles Street, San Diego 92106. — **Hal Seykota**, Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

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Rumor? By your reading the rumor of a party for Class of '40 will have been confirmed or laid to rest. **Jim Rumsey**, the Class president, is instigating an impending 37½ year reunion, perhaps in Europe or in Mexico or ???, and has asked in his Alumni Fund letter that those interested send him a card. Jim's address is 809 Westover Rd., Wilmington, Del. 19807. I shall try to have accurate information, yea or nay, in this column next month. He sounds as if he did not need too much encouragement, but would like your response.

Fund Reminder: If you have not responded to the alumni appeal for gifts, put it off no longer. The most notable feature of this year's drive is the anonymous matching gift, dollar for dollar for an increase of $25 or more, up to $1,000.

Soyer, Ritz, Escoffier: No, not Class of 1940 graduates, but names from the past of *Creative Chefs and Great Gourmets*, not surprisingly written by **Sam Goldblith**, the Professor of Food Science at M.I.T.

Jim's Neighbor, John: **John McKay** has retired from his job in industry, and made his first major task his re-election as State Representative, 13th District, of Delaware. McKay presented himself as a member of the Republican team, from Ford (President) to Washam (Sheriff). Politics on such an active level is probably unusual for M.I.T. graduates. Are there any others out there? — **Frank A. Yett**, Secretary, 1405 Ptarmigan Dr., Walnut Creek, Calif. 94595

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I always like the notes that say, "moved to the country." This time it's **Lyle Richardson, Jr.,** who has moved to Crawford Notch, N.H. Lyle is Associate Publisher and North Country Editor of *New England Outdoors* which he started with two others in October, 1974. His mailing address is: Box 246, Bartlett, N.H. 03812, and visiting address: Davis Park, Harts Location (population 16). . . . Mrs. **Edith (Rovner) Corliss** writes that she is now a "hardback" co-author of National Bureau of Standards Handbook 119: *Quieting: A Practical Guide to Noise Control*. . . . I visited **Howie Samuels** when I was in New York City and he had just received a handwritten letter of appreciation from President-Elect Jimmy Carter. Howie is doing consulting for the Proudfoot Corp. . . . **Ralph Landau**, Sc.D. '41, continues in the news. *Chemtech* magazine carries the article "Enduring need for Entrepreneurship." I agree wholeheartedly with his statement: "The pitfalls staring every potential entrepreneur in the face are numerous. They include being spread too thin, inadequate initial financing, insufficient balance of skills (i.e., too much technical knowledge but not enough production or marketing know-how), lack of attention to legal and regulatory problems, and tax and political unsophistication. There are others, including of course the distinct possibility that the country doesn't need the IDEA after all!"

Knut Johnsen, who works for PPG in Lake Charles, La., was in town and he hasn't changed much from 35 years ago. . . . **Alan Surosky** who "retired" to Florida, is back in the consulting business with a company directed toward naval operations called S.E.A. (Scientific Engineering Analysis). He is happily remarried living in Clearwater, Fla.

Keep sending in the news. — **Henry Avery**, Secretary, U.S.S. Chemicals, 2863 - 600 Grant St., Pittsburgh, Penn. 15230

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George Freedman was elected chairman of the board of governors of the International Microwave Power Institute at the technical society's annual meeting last September in Belgium. This worldwide organization is concerned with nontechnical applications of microwave power, such as heating, cooking and energy transmission, and provides a forum for academic, industrial and government authorities concerned with the design, manufacture and application of microwave equipment. George is manager of the New Products Center of the Raytheon Co. Microwave and Power Tube Division in Waltham, Mass. He has a master's degree from Boston University and holds many patents on electron tubes, semiconductors, materials and applications of microwave power. He is currently an advisory editor of *Solid State Technology* magazine, and he and Ruth, who have two children, live in Wayland, Mass.

Bob Reebie sent in a note, quote: "Good fortune has smiled upon Reebie Associates and we have moved to larger offices at 200 Railroad Ave., Greenwich, Conn., so as to be better able to serve our consulting clients in all modes of transportation. **Hank Tiedemann** has moved his marine engineering firm nearby. ". . . The class spirit is still high, and I am always pleased to hear that you call on one another in your travels. I have

How Massachusetts Can Meet Its Problems with Confidence in 1977

What's ahead for Massachusetts in 1977?

Good things — "a year when Massachusetts will solve some problems," says William S. Edgerly, '49, Chairman and President of the State Street Bank and Trust Co. of Boston.

There are plenty to solve, Mr. Edgerly admits in an article written especially for a New Year's survey in the *Boston Globe*: serious financial problems for the state and for its largest city, Boston; division and fear of violence in Boston schools; concern for the business climate in Massachusetts, based on high taxes and the high costs of doing business in New England.

But Massachusetts ended 1976 with some positive attitudes about its problems and how to solve them. Economic growth — jobs and the business climate — became "top priority" subjects. People began to talk realistically about cost-effectiveness in the operation of state and municipal governments and about a long-term perspective for Boston schools. There may be better control over school spending in many Massachusetts cities and towns and an expanded state sales tax to "roll back the state's excessively high property taxes."

"A focus on solving problems together should help build confidence and a spirit of cooperation in 1977," wrote Mr. Edgerly. Bicentennial events, he said, demonstrated "the depth of good will that exists in this Commonwealth. If we apply this spirit to solving a few long-standing problems, the year 1977 may see us move ahead more than usual."

found that if you take the time before a holiday or business trip to read the 25th Reunion Book, or the latest M.I.T. Register, you will find a classmate you know in an area you are going to visit, and nothing is more fun than an evening together. Try it, . . . you'll like it. — **Richard M. Feingold**, Secretary, 779 Prospect Ave., West Hartford, Conn. 06105

44

When we receive the notes you have sent on the M.I.T. Alumni Fund envelopes we are reminded of the brief notes many of us add to our holiday cards to bring our friends up to date on our lives. We're pleased you took the time to bring us up to date about you and provided us with the news to help fill this column.

The widow of **Dennis H. Groome, Jr.**, informs us through the Alumni Records of his death in July of 1976. His last address was Metairie, La. . . . **Kenneth M. Rehler** writes from Los Angeles that he is semi-retired and is doing some computer consulting, along with sharing management duties with his son Mike on apartment buildings they own. Ken plans to retire to Lake Tahoe where he goes three times a year to visit his daughter, son-in-law, and two granddaughters.

Jose M. Aguila writes that he is still living in Caracas, Venezuela, where he and **Dick Lopez** have a manufacturers' representative business employing 50 people and a transformer manufacturing plant employing 125 people. He says business is good, is still growing, and they are getting more than their share. . . . **William A. Jack** has returned to the Ralph M. Parsons Co. as Manager of their Power Division and as a Senior Vice President. . . . We received a nice letter from our class president, **John L. Hull**, asking for a "Class of '44 Bread Tray," (available for $10.00 if sent within the U.S. mainland, with proceeds to the class treasury. John was married in March of last year and he and his new wife moved into a new home in July. John is treasurer of the Bucks County Symphony this year and is still (after 23 years) a playing member of the group.

The class trays are solid items of Armetale ® metal, 24x17x2 cm. They are shaped like a truncated ellipse and in the center well is the M.I.T. seal. The trays are a result of the 30th reunion planning activities of Ruth and **Norman Sebell**, who worked out the arrangements for the enjoyments in Bermuda in 1974. They can be ordered through us and are sent to you by U.P.S. — **Melissa** and **Newton Teixeira**, Secretaries, 92 Webster Park, West Newton, Mass. 02165

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The only thing colder than Ohio is the response we are receiving in the mail this time of year. Gentlemen, ladies, we must receive letters if we are to write the class notes for each issue. Please write the class secretary!

Last summer, **Ned A. Spencer** and several of his associates at the MITRE project were presenting a demonstration of a new airborne collision avoidance system designed by MITRE. The demonstration was held in Washington and was presented to the F.A.A. and Air Transport Association. From a small antenna on a Washington building, "interrogations" were sent and received by a large number of especially equipped aircraft flying over the area. A mini-computer and a glowing screen provided tracks of the aircraft. The aim of the MITRE project is to alert aircraft of possible mid-air collisions and these tests are part of the development of project.

William F. Brace is one of two named to the newly established Cecil and Ida Green Professorships of Earth Sciences in the Earth and Planetary Sciences Dept. of M.I.T. Dr. Brace, who is a professor of geology, is considered one of the world's outstanding scientists in his field. His experiments in the laboratory have opened the way to earthquake predictions before precursors were discovered in the field. Dr. Brace is a member of the National Academy of Sciences and a Fellow of the Geological Society, and the American Geophysical Union. Professor Brace received his three degrees at M.I.T. beginning with a S.B. in naval architecture and marine engineering in 1946, a S.B. in civil engineering in 1949, and a Ph.D. in geology in 1953.

Best wishes for a happy and healthful New Year to you all. — **Russell K. Dostal**, 18837 Palm Cir., Cleveland, Ohio 44126

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I just spent eight days in Florida playing golf and it appears that all of you have been vacationing somewhere as well — the mail bag is virtually empty.

Fred Grant dropped a note to say that on November 11, 1976 he was married to Gloria Grace Goepfert Froehlig. They are residing in Newport News, Va.

You have all received the reunion announcement from **Don VanGreenby** and I trust that you have sent your dues to **Parker Symmes**. We are looking forward to seeing many of you then.

Drop a line. — **Dick O'Donnell**, Secretary, 28516 Lincoln, Bay Village, Ohio 44140

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Cornelius L. Hudak has been appointed sales manager for the Metals Division of Century Brass Products in Waterbury, Conn. Cornelius has over 27 years of experience in the sales management and marketing of brass and copper-wrought products. With Century Brass, he will have complete responsibility for directing and coordinating the sales force of the Metals Division. Cornelius was executive vice president and then president of Plume and Atwood Industries between 1963 and 1972. In 1972, he joined Volco Brass and Copper as assistant to the president and executive vice president, and in 1975 he joined the Riverside Metals Division of Root Industries as plant manager.

John C. Avallon was appointed president of GTE Sylvania. John had been a senior president of the Group. Since joining Sylvania in 1952 John has held a number of engineering and management positions. John was named general manager of the lighting equipment division in 1964 and in 1967 became vice president for Lighting Equipment and Special Products. Four years later, he was appointed vice president for research, engineering, and special products for the lighting products group.

In May **Bill Weisz** received the Honorary Doctor of Business Administration from St. Ambrose College in Davenport, Iowa. The honorary degree was conferred at the college's commencement ceremonies. Bill was elected Vice Chairman of the Board of Governors of the Electronic Industries Association for a term that begins on January 1, 1977.

John L. French, manager, product research, Deere & Company Technical Center, Moline, Illinois, has been elected a Fellow by the American Society of Agricultural Engineers. Fellows are honored for their contributions to the advancement of agricultural engineering. John joined Deere & Company in 1948 working in the inspection and mechanical departments. John designed a platform lift and assisted with the design of gearing on a windrower and a power steering system for Deere's 45 combine. He supervised design of wheel and crawler loaders, bulldozers, backhoes, elevating scrapers, and hydraulic pavement breakers. John holds 11 U.S. patents and 20 international patents for his equipment designs.

John Farrow and his wife, Dot, are the new owner-operators of Southwinds Motor Court of Dewey Beach. Dewey Beach is located two miles south of Rehoboth Beach, Delaware, on a narrow stretch of land between the Atlantic Ocean and Rehoboth Bay. John and Dot are inviting guests to come and explore the miles of wide sandy beaches. Swimming, sunbathing, boating, fishing,

and crabbing are just a few of the many activities available (in season). They are located 115 miles from Washington, D.C.

Merle K. Loken received an Alumni Achievement Award from Augustana College in Sioux Falls, South Dakota. Merle has a Ph.D. in biophysics and an M.D. from the University of Minnesota. He is a professor and Director of the Division of Nuclear Medicine at the University of Minnesota's Medical School.

Thomas O. McNearney, Jr. has been named chairman of St. Louis Federal Savings and Loan Association. John had been executive vice president of the Association.

Dan Fink, Vice President and General Manager of the Gereral Electric Space Division, was named a Fellow of the American Association for the Advancement of Science. Dan was cited for his pioneering work in the dynamic analysis of aircraft, his contributions to the direction and control of research and engineering in strategic offensive and defensive weapon systems, and for his leadership in the development of the world's first earth resources satellite — Landsat.

Alan M. Kriegsman, a writer for the *Washington Post*, received the Pulitzer prize for criticism. This was the first award of a Pulitzer to a dance critic. Alan was recently a member of the Visiting Committee on the Humanities at M.I.T. In addition to being dance critic, Alan writes a Sunday column, "Crosscurrents," which explores in-depth cultural trends and issues. He also covers news events related to culture. These have included stories on the National Symphony strike, U.S. House and Senate hearings on various art bills, and Presidential press conferences.

Dave Finnegan is plant manager for a small company in his field of chemicals and plastics. This is the first time in six years that Dave has worked in chemicals and plastics. Dave started his own molded product business on a part-time basis in 1972. The class of '48 bought molded miniature beavers which were mounted on molded bases. Everyone attending our 25th Reunion received one of these attractive souvenirs. Dave currently has expanded the product line to include souvenirs for Boy Scout activities, miniature furniture, and doll houses. His business is still limited to a part-time activity. Dave is still active in Boy Scouts. He now is Troop Leader Development Coordinator for R.I. and was course director this past summer. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

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I have two letters from the wives of classmates. Aileen Howell sent an announcement that **Sidney C. Howell** was elected President and Chief Operating Officer of the Weatherhead Company last January. Aileen also reports that their daughter Wendy has a teaching assistantship at Ohio State University where she is getting her master's degree in zoology.

Barbara Gehl writes: "This is to inform you of the death of **William H. Gehl, Jr.** He died on September 1, 1976 just two-and-a-half weeks after we moved to Wisconsin. Bill passed the C.P.A. exam last year and was preparing to enter into a new career. In February of 1973 he had been awarded an M.B.A. from Loyola. The three younger girls and I will make our home here temporarily until we can make a considered decision. Bill was always proud of M.I.T. and the people whom he knew there. I think M.I.T. can be proud of him, too. He was more than a man with a fine mind; he was a deeply concerned human being, as evidenced by his volunteer work at Marillac Settlement House, president of Marillac High School Parents' Club; advisory member and President of Religious Education for St. Paul of the Cross parish, chairman of the Heart Fund in Kankakee, and member of the Industrial Park Development Board in Kankakee. There were other gifts of self that Bill made to his community in addition to his full-time work for almost 23 years at North Illinois Gas Co. He was a wonderful husband and a *super* father. The world is poorer for his passing." Thank you for the letter, Barbara; our best wishes and condolences to you and your children.

From Technology Fund Newsnotes came the following four items: **L.S. Ashley** retired from the U.S. Navy in September, 1975 after 30 years and 3 months of commissioned service. He is currently serving as a consultant to Inter-National Research Institute in McLean, Va. . . . **Ken Prytherch** reports that his daughter is finishing up a second degree at M.I.T.'s Sloan School and a son ditto at N.Y.U.'s Graduate School of Business. He feels he can see some light (however dim) at the end of the financial tunnel. He notes plaintively that the dog and he are the only members of the family without advanced degrees! . . . **Nathan Sokal** also has a family of college students. His son graduated from Harvard summa cum laude in June, 1976 and is now a graduate student in theoretical physics at Princeton. Both daughters are at Yale.

I wish that 1977 will be a good year for all of us. Fondest regards. — **Frank T. Hulswit**, Secretary, 77 Temple Rd., Concord, Mass. 01742

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It is with great sadness that I report the death of **John T. Weaver**, who has been our Class Treasurer since 1950. Many of you were fortunate to know Jack in his undergraduate days — he was a popular member of the Walker Memorial staff — and others of you have come to know him well through his participation in class activities and Alumni Council. None of us who attended the 25th Reunion will forget how much Jack's efforts contributed to its success. His enthusiasm, unselfishness, and commitment sparked every organization and committee he joined, and the contributions he made to his profession, his college, his church, and his community will long be remembered. I was privileged to have Jack as one of my closest friends (he was a neighbor for the last 20 years), and I feel a deep personal loss at his death. Jack leaves his lovely wife, Ruth, and eight children; she has asked me to thank all Jack's classmates for their kind expressions of sympathy.

Effective October 1, **Donald B. Brah** is South American Region Manager, Power Line Carrier International Marketing, General Electric Co., with headquarters in the Lynchburg, Va., plant. Prior to this appointment, Don was Manager for Line Coupling Equipment in G.E.'s Power Line Carrier Engineering Section.

Charles C. Park, Executive Vice President of The Gleason Works, is a new member of the Board of Trustees of Keuka College, Keuka Park, N.Y.; he and Mrs. Park are the parents of a former Keuka student. Charlie joined The Gleason Works in 1940, and he currently serves as Director of its International Sales Corporation and President of its International Marketing Corp. He is a Director, too, of Gleason Works, S.A. de C.V. in Mexico, Gleason Works, S.A. in Belgium, Gleason Works, Ltd., in England, and Gleason Works GmbH in Germany; and he is Chairman of the Board of the Cunningham Corp., a wholly-owned Gleason subsidiary.

We regret to announce the death of **Peter V. Ritner**, who achieved recognition in the publishing world in 1969 when he negotiated the purchase of Albert Speer's memoirs of life in Nazi Germany. — **John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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Here are short notes for a short month. **George A. Bradley**, who has been technical director at Bridgeport Brass in Bridgeport, Conn., has been given the added responsibilities of metallurgical and manufacturing process engineering of the company's brass mills. George went to Bridgeport Brass directly from M.I.T. as an assistant process engineer. He then moved to a company plant in Adrian, Mich., in 1954 and returned to Bridgeport in 1958 as staff process engineer.

1960 he became superintendent of process engineering and in 1964 was named technical director. He is a member of the American Society for Metals and American Society for Mechanical Engineers. George lives in Fairfield, Conn.

James R. Strawn, a geophysicist with Chevron Oil Co., writes that he attended the Society of Exploration Geophysicists Convention in Houston as a member of the Council and the Government Affairs Committee. He was pleased to see other members of the class there, including **Milo Backus**, session chairman, and **Phil Hallof**, **Don Grine** and **Parker Gay**, all of whom represented companies with exhibits at the convention. . . . After a stint as Professor of Environmental Science at the now-defunct New College in Sarasota, Fla., **Gene Rapperport** is a materials and design consultant, self-employed and loving it. Gene has two children in college at Cornell and Harvard and a wife working as an architect to help keep them there.

Sarkis Zartarian writes that he and his wife Nancy and three children live in rural North Carolina in a home which they built mostly by their own labor. Sarkis is enjoying his job with I.B.M.'s Systems Communication Division; he has been with I.B.M. for nearly ten years. A few years ago Sarkis was working on new products for the electronic point-of-sale application in retail stores and supermarkets, but for the past few years he has been supporting division management in the areas of revenue and financial performance. . . . **James Stolley** writes that he has three children, two girls and a boy, currently attending Middlebury College in Vermont. He says that it solves his problem of all that excess cash lying around! — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass 01741; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto. Calif. 94301

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Dear Classmates: My mailbox is just plain empty. And I can think of no foolish or non-foolish "war stories" to tell. Except — **Jay Berlove** is now wandering around in Dallas; so all gamblers are forewarned. For garden seeds, please do keep in touch. I need your help to fill this column. — **Martin Wohl**, Secretary, 7520 Carriage Ln., Pittsburgh, Penn. 15221

54

As you curl up by the fireplace with your copy of *Technology Review* to warm the cockles of your heart — greetings. Hope the Holidays went well with you.

Manny Pazar has been with Vappi & Co., General Contractors, in Cambridge since graduating with us way back in '54. He is presently General Superintendent of Construction. He has been doing a little construction on the side. He has two fine boys and a darling girl (ages 17, 15, and 10). Both boys are Eagle Scouts. The Allan Gottlieb puzzle of the month is for you to figure out how old Manny's daughter is.

Andy Kariotis is President of Alpha Industries, Inc., of Woburn, Mass. Alpha is a manufacturer of semiconductor and solid state microwave components. His company does about $8 million annually and is on the AMEX. Andy lives in Wayland, Mass.

Phil Rane, M.D., was recently made a full partner in North Shore Radiological Association. He is currently Chief of Nuclear Medicine and Ultrasound and Associate Radiologist, Hunt Memorial Hospital in Danvers, Mass. Phil is also Vice President, Wakefield Office Corp.

Dean Jacoby's Christmas card updates his activities and reports that former roommate **Bob Anslow** is Manager of New Business Development for the Semi-Conductor Division of Rockwell International.

Mark Caplan formed a new company called Xenergy about 15 months ago. They are doing work in energy conservation. **Stan Kolodkin**, Jay Silverston '55, and Lucille Roselman are also principals. Mark lives in Concord, Mass.

Gordon Smith is in Ridge Field, Conn. He is presently operating an electronic control business slanted towards industrial uses. Our business slants, too, Gordon — only to the red.

Bill Eccles reports that he is delighted that after three years as Head of the Department of Mathematics and Computer Science at University of South Carolina, he has resigned to become a regular faculty member. It is the first time in Bill's academic career that he has not had administrative duties and he is enthusiastically looking forward to it. Much better solving integrals and counting bits than processing raises or answering affirmative action questions, eh Bill? **Bill Steyert, Jr.**, wins our quiet man of the month award. Bill writes that he is in Los Alamos, N. M.

Ned Lyke is a real estate developer in Glenville, Ill.; he heads Lyke Realty Co. Ned's company will handle construction or development projects in Illinois or Wisconsin. He also has a management company that operates in these states and they have over 250 apartment units. Ned sounds happy and enthusiastic and we are glad to see another classmate has found his path of success. — **E. David Howes**, Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaries: **Charles Masison**, 76 Spellman Rd., Westwood, Mass. 02090; and **Lou Mahoney**, 6 Danby Rd., Stoneham, Mass.

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Greetings to one and all! And a belated best wishes for the New Year to all of you out there from your two correspondents.

Some weeks ago the New York member of this dynamic duo was called upon to participate in an Alumni Fund Callathon. Eager to kill two birds with one stone, I chose to call members of our class. The biographical data gathered during the ensuing conversations is noted below. Parenthetically, I might urge each of you to take advantage, if possible, of the two-for-one leverage of the "M.I.T. Challenge '77" program prior to the conclusion of the Alumni Fund drive in June.

I received a nice report from **Stan Amstutz** who is living in Ann Arbor, Mich., where for the past four years he has been the vice president for product development of Comshare Inc., a time-sharing company. Prior to that Stan was with Sylvania for some ten years. Stan's family includes two little girls, aged 6 and 8. . . . **Walter Brillhart** reports that he is the vice president of the National Weather Corp., a corporate aviation services outfit in Newark, N. J. Walter's family includes a boy and girl, aged 16 and 13, respectively.

John F. Gahran's wife reports that Jack started a successful management consulting firm, Gahran and Co., about a year ago. He has also since taken part in the organization of an additional concern, Community Recreation Inc., which is engaged in the marketing of "Skate-On," a plastic material used to simulate ice. Nor has Jack been derelict in family development. His family currently includes six youngsters ranging in age from 8 to 18; as of this writing his oldest daughter is a National Merit semi-finalist.

Robert C. Grout's son reports that Bob is currently the manager of Technical Support Services with Eastman Kodak in Rochester. Bob's son, John, may be following his father's footsteps at Tech next year. . . . **Frederick Lupton II**, formed a consulting and general engineering concern, Bell and Lupton Engineering, in April, 1976. The professional staff of Fred's young outfit has already doubled. Apparently heart problems with which he has been beset over the past two years have not affected Fred's vigorous activities.

Professor **Marvin Tanzer** is involved in his ninth year of research and teaching in the Department of Biochemistry at the University of Connecticut Health Center. Marvin reports that during the 1974-75 school year, he received the Macy Foundation Faculty Scholar Award, enabling him to spend a sabbatical year in Belgium, conducting research on human connective tissue. Marvin has also had time for four children, ranging from age 21 down.

That about summarizes the news from here. Do write — it is a pleasure to receive mail other than the usual stack of bills. — Co-secretaries: **Marc S. Gross**, 3 Franklin Ct., Ardsley, N.Y. 10502; **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass. 01890

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Joan and **Bob Malster**, pictured on this page, have been important leaders of our class. Bob was class president for a decade, from 1961 through 1971, and has been active in our reunions and other class functions. He is Senior Manager of Manufacturing at Polaroid, and is responsible for all their contracted camera production — that is all products but the SX-70. Bob joined Polaroid after getting his S.M. in Chemical Engineering at Tech. Bob and Joan live with three children in Wellesley. . . . Also at Polaroid is **John Gignac**, Manager of the Photographic Standards and Systems Lab in the quaint old Cambridge building, shared by Dr. Land's personal lab, from which A.G. Bell sent the first phone message 100 years ago. Take note, those of you who complain of outmoded research facilities! John and Joanne live in Southboro with three children. . . . Another of our class, **Lloyd Beckett**, is with Polaroid, as Manager of Quality Control for the Camera Products Division. . . . **Richard Finn** has been around the campus a lot recently, as Project Manager for Vappi and Co. construction firm, responsible on-site for the new Chemical Engineering building at M.I.T., and before that the new Electrical Engineering building. Richard and his wife live in Lexington with three daughters.

Mary Fawcett McNulty has practiced architecture in Lincoln, Mass., with her husband Tom of Course IV '49. Recently she has been on a research project on vernacular architecture for the National Endowment of Humanities. Her forthcoming book on that subject concerns the integration of design and construction into local culture and environments. She also teaches at the Boston Architectural Center, and has founded the Design Guild. . . . **Victor Bauer** went to Harvard for his Ph.D. in chemistry, and was with Merck for many years. He is now Vice President for U.S. Operations, in Somesville, N.J., of the German firm, Hoechst-Roussel Pharmaceutical. **John Cronin** has been with Pfizer Chemical in New York City for nine years; currently he is in the finance function of the International Division. He and Lois and three children live in his old home town of Scarsdale.

Lindley Squires was recently appointed director of Project Management for I.T.T. Avionics Division in Nutley, N.J. He's been with I.T.T. since graduation; and lives with his wife Edwina and two daughters in Upper Montclair. . . . **Ed Pease**, Vice President of the Investment Services Division of Chase Manhattan Bank, attended a White House dinner last fall to honor Martha Graham. Ed is treasurer of her Center of Contemporary Dance in New York City. . . . **Eugene Amazon**, a Computer Consultant in Geneva, recently reported on several meetings of the M.I.T. Club of Switzerland.

Andy Edmonds, a new Vice President of our class, is treasurer of I.D.R. Inc. in Needham, Mass., a small firm manufacturing test instruments, with M.I.T. a major customer. He is living in Osterville on Cape Cod, and spends some winter time aboard his boat near Palm Beach. . . . **Bruce Bredehoft**, our permanent co-secretary, has moved from Loomis Sayles in Boston to Investors Diversified Services in Minneapolis, still in the profession of investment research and analysis but with a significant new opportunity. Bruce started there in December; and Marion and the family moved into a new house, (address below) in February. They have some enticing observations on the professional, cultural, residential, and other advantages of life outside the Boston area — but some of us won't even listen (yet). Please let's here some news. — Co-secretaries: **Bruce Bredehoft**, 7100 Lanham Ln., Edina, Mich. 55435; **Warren Briggs**, 33 Bancroft Rd., Wellesley Hills, Mass. 02181

60

Two new enterprises have been started by members of the Class of 1960. **John Boatwright** resigned the presidency of Northeast Electronics Corp. to form Sigma Four, Inc. John's company is in Concord, N.H. It specializes in products for operating telephone companies. . . . If you happen by Harvard Square, drop in at Ahmed's, a restaurant and bar opened by management consultant **John Windle**.

Norman Vadner is treasurer of Christiana Metals in West Chester, Penn. . . . **Lawrence Kravitz** has settled in Aberdeen, Md., where he is making a new career as an operations research analyst with the Army Materiel Systems Analysis Activity. . . . **Mike Padlipsky** reports that he is "back in the Boston area (Burlington) after 20 months in The Diaspora (a.k.a. the Washington, D.C. area)." To you non-Course XXIB cognoscenti, that means Mike thinks Boston is where it's at.

Dan Whitney is managing projects related to industrial automation — primarily computer-controlled robot arms for assembly — at the C.S. Draper Laboratory. Dan's wife, Cynthia ('63), is a physicist at the Draper Lab, where she is working on the scattering of sun and laser light in the atmosphere. . . . **Bill Kleinebecker** is a marketing adviser with IBM in White Plains, N.Y. Bill lives in Wilton, Conn., with his wife and four children, ages 11, 9, 7, and 5. He saw **John Hartung** recently; John is with Rayonier and lives in The Big Apple with his wife and two children (7 and 5). . . . A second daughter, Kay, arrived on November 11 to make **Bill Nicholson** the father of three. Bill is with the Potlatch Corp. in San Francisco, where he is corporate energy coordinator.

Incidentally, I calculated the center-of-gravity of this month's newsmakers and it came out just west of Jamestown, Diaspora. So keep those cards and letters coming, wherever you are. — **Robert F. Stengel**, Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

63

December, 1976. Writing this column . . . television on in the background . . . weatherman reporting record lows in Boston, 30 below in Minnesota, I know why so many of the class of '63 have migrated west. The air tonight is warm and balmy, and the New England winters of the early 1960s seem very, very distant.

I haven't much news this month. There is a midwinter drought in returns of alumni fund envelopes. **Pat Selby Marzilli** worked this past year in the Biology Department at Johns Hopkins in metalloenzyme research. She is now enjoying a short "retirement" after the birth of her third child, Alisa Francesca, born on September 7. Last summer Pat and her family toured the western national parks and attended a number of chemistry conferences. On the trip the Marzillis visited **Deanne Gross Dickerson** in Boulder, Col.

A news clipping informs us that **Roger Elton** has received his C.P.A. certificate in Nevada. In addition to his B.S.E.E. Roger has an M.B.A. (Harvard), law degree (Santa Clara), and now the C.P.A. A man of many talents, Roger is practicing law in Reno. . . . **Bob Vernon** has recently been named Vice President, Marketing and Business Planning for the Europe-Asia-Africa Division of Sperry Univac. Bob has been with R.C.A. and Sperry Univac for 12 years, moving from systems analysis to sales, sales management, and product planning. Bob is living in Surrey, England, with his wife and two children.

I wrote a few months back that I had visited **Larry Beckreck** and his family during a trip to England. This month Larry repaid the visit here in California. He had been on a swing through Latin America and the U.S. for Genesys, selling special purpose software for civil engineering applications. England, California . . . what continent is next?

Hope you had a good New Year, and are all surviving the rigors of winter. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

64

Greetings, '64! Not much in the way of news lately. All I received this month were two alumni fund envelopes and two news clippings.

Doug Tuggle wrote that during the spring semester of 1977, he will be Visiting Associate Professor of Administrative Science at Rice University in Houston, Texas. The second note came from **Donald Reed**. Don resigned as Vice President and Chief Geologist of Haley & Aldrich, Inc. in December, 1975 and entered "private practice" as a consulting geologist.

The Lahey Clinic foundation announced the appointment of **Roger Hybels** to associate staff member in the Department of Otolaryngology at the Lahey Clinic in Boston. A most interesting news clipping about law student **Leon Kaatz**: passing the Connecticut Bar in October, he is now Attorney Leon Kaatz. Leon opened an office for the general practice of law in Hartford in association with lawyers Corneal and Mrtotek.

We are spending the holiday season at home. Christmas is typically a low activity period of the year in Washington, and the change of administrations doesn't alter that basic character of the area. It's a good time to see the city — without the attendant (Bicentennial) crowds which have been ever present since our arrival on the scene 18 months ago. There is some extra activity in and around Pennsylvania Avenue, as one might expect, but it's mostly the assembling of grandstands, barricades, tents, and the like for the inauguration. This will be our first, as "locals" and we are looking forward to it.

Remember the 'tute! Ciao! — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md.

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Steve Lipner passed along a nice letter from **Dan Murphy**. Dan and Sara, '68, are still living in Framingham and both are working at Digital Equipment Corp. Dan is a software engineer in the Large Computer Group and recently became president and partial owner of radio station WCAS in Cambridge. . . . **Francis Gerstle** is living in New Mexico and working for Sandia Labs; he is in charge of composite materials development. The Gerstles have two sons, 5- and 2-years old. . . . **Harry Movitz** reports that he took a cross-country trip last winter from Massachusetts to California, with 26 states in between. He was unclear whether this was a vacation or a move from the note, though I think the former. Harry now owns a "landscape and a computer sofware company." . . . **A. Robert Chincillo** has been promoted to manager of the radome section of Raytheon in Bedford, Mass. To keep busy he is also working for an M.B.A. at Boston University.

We took Bruno with us for some sledding and cross-country skiing, but his St. Bernard blood is getting thin and he prefers a nice fire. That's all the news for now, folks. Please write. — **Edward P. Hoffer**, Secretary, 12 Upland Rd., Wellesley, Mass. 02181

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Matt Fichtenbaum gets the monthly distance award with the following correspondence: "In July of this year I took a leave of absence from my job with GenRad (formerly General Radio), and came to Sweden where I am a visiting assistant professor in electrical engineering at the University of Linkoping. Judy and I are enjoying the change of environment and I am enjoying the 'sabbatical' in my work. Any readers who expect to find themselves in the vicinity (about 200 kilometers southwest of Stockholm) are welcome to come by for a tour and visit. My address is: Department of Electrical Engineering, Linkoping University, S-581 83 Linkoping, Sweden."

Chuck Davis, wife Nancy, and their children, Sarah who is 4 years old and Rebecca 10 months, have moved to Cincinnati where Chuck has a fellowship in pediatric nephrology. He expects to finally finish training and look for a job in 1978.

Joan and Bob Malster, '56, Class President from 1961-1971, enjoying the 20th Reunion activities of last June. Bob is Senior Manager of Manufactoring at Polaroid Corporation.

. . . **Ralph Schmitt** left Aerospace in 1972, and joined R&G Sloane Manufacturers as Vice President of Manufacturing. He is busy with plastics (e.g., bathtubs, yachts, pipes and fittings) and enjoyes a broad range of management responsibilities.

Tom Gomersal passed the exam given by the Society of Actuaries last May, and is now an Associate of the Society. His son's painting was selected as the Connecticut Christmas Seal Picture for 1977. Look for it when you receive your seals next year. . . . **Hans Juvkam-Wold**, his wife and two children aged 7 and 4, are enjoying cross-country skiing in the area of the "Mile High City" (Denver) where Hans is Director of Special Projects with Gulf Mineral Resources Company.

The news is still too sparse. Let's hear what you are doing. — **Paul Rudovsky**, Secretary, 340 East 64th St., Apt. 10B, New York, N.Y. 10021

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Keep our class reunion on your calendars for June 9 to 12.

Gerald Tomanek has left Acurex Corp. to become General Manager of Time and Space Processing, Inc., in Palo Alto, Calif. He and Susan have a 1-year-old son, Stuart. . . . **J. Peter Bartl** is an officer in M.I.T.'s Industrial Liaison Program. He recently spent three years in industry with AMP, Inc. . . . **Bill O'Day** is with the Process Machinery Division of Rexnord in Milwaukee. He previously worked at Banco Lar Brasileiro S.A. in Rio de Janeiro and at Kennecot Copper Corp. in Lexington, Mass., and he received an M.B.A. in finance in 1974. . . . **June Maul** teaches in a private high school in New Jersey and is in a Ph.D. program in science and education at Rutgers. She and Mike raise Belgian sheepdogs. . . . **Ken Kiesel** has acted in several plays in Southampton, N.H. . . . **Rod Peterson** recently accepted a design engineering position with Dynamic Engineering, Inc., Newport News, Va., a small firm specializing in the design and fabrication of wind tunnel research models. He writes, "For the first time since graduation I am practicing real, live engineering. After nine years in the construction end of the shipbuilding business (where some techniques date back to the enicians), it is quite a change to be working with the research and development programs of the aerospace industry."

Doug McCraith and his wife have their first child, Andrew Douglas, born September 28. . . . **Ken Finn** writes that he is living in a prerevolutionary farmhouse in Pound Ridge, N. Y., and is consulting in organization development for General Foods in White Plains. . . . **Chuck Greene** writes documentaries and dramas for TV and industrial film and produces some TV in Toronto. He is still trying to develop a place in the country. . . . **Richard Cunningham**, supporting a human life amendment to the U.S. Constitution, ran for a U.S. Representative from Connecticut. He has a law degree from Duke. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

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Greetings again from your nation's capital. We just returned from an eight-day sailing trip through the British and American Virgin Islands together with Bev and **Bill Carlson**, which did a great job warming us up after freezing here in the northeast. However, now we have to get back to work. .. Out in Berkeley, **Scott Davis** is studying for a doctorate in what he calls "mathematical neurophysiology." . . . Meanwhile, in the colder parts of the country, **Karl Hella** is teaching economics and completing a dissertation at St. Olaf College, and **Douglas Goodman** is studying math at the University of Minnesota where his wife, Barbara, is a graduate student in physiology.

Mike Jaffin decided to get away from it all. Taking a leave of absence from a residency in surgery, he served as a trip physician on a trek to Everest last fall. His wife, Dawn Wood, is now finishing her M.D. degree. . . . **Steve Gamer** is working as a programmer at Raytheon Submarine Signal Division in Rhode Island. . . . After spending a year in England and a year in Spain, **Robert Jacobus** has returned to the U.S. to work for Sweda International on software systems development. He bought a century-old farmhouse in New Jersey which he and his wife are restoring.

Back in California, **Mark McNamee** is enjoying his position as Assistant Professor of Biochemistry at U.C.-Davis. He and his wife, Carole (Simmons '69), have two children, Mark, 1, and Elizabeth, 3. . . . Having spent October, 1974-October, 1975 at CERN in Geneva, **Shirley Jackson** is back stateside at the Fermi National Accelerator Lab. . . . Kathy and **Paul Miller** and son, P.J. Jr., 1, are now in San Diego where Paul is the Public Works Officer at the Marine Corps Recruit Depot. He recently received an S.M. from the 'tute. . . . **Tom Romer** is teaching economics at the Graduate School of Industrial Administration at Carnegie-Mellon. . . . Back in Cambridge, **Darryl Pomicter** is with Advent Corp. as international marketing manager for their VideoBeam ® TV system. . . . Also in Beantown is **Paul Ware** who is working for Polaroid's film division in Norwood as senior Q.C. engineer on both the SX-70 and Pronto! cameras.

Marty and **John Vitek**, along with children Chris (6) and Sarah (3) have returned from a three-year postdoc in Germany and have a slight case of culture shock. They are living in Cheshire, Conn., while John works for Olin Corp.'s Metal Research Lab in New Haven. . . . Nancy and **Harry Goldmark** are living in New York City where he is in his second year of residency at the Hospital for Special Surgery in orthopedic surgery. . . . **Rick Lufkin** has moved from Corning, N.Y., to Wellesley Hills and is now an assistant vice president for American Research and Development.

Drop us a line if you have the time and we'll see you next month. **Gail** and **Mike Marcus**, co-secretaries, 2207 Reddfield Dr., Falls Church, Va.

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I received a long letter from **James Korff** postmarked Sao Paulo, Brasil. He states that it's been 18 months since he had last received via this magazine any offical news about former soccer teammates and "tech tools." After receiving his master's in architecture at Berkeley and seeking employment in the Bay area, James moved to Brasil to work for a design group in a large construction firm. He then left that position after designing an embassy building. Although currently self-employed on small commission jobs, he expects to be in the New York area for social, cultural and occupational advantages.

Maggie and I have succeeded in increasing the number of applicants for M.I.T. Class of '99 with the birth of Sean Robert. My trial work may take me to Chicago for criminal appeals and our tentative travel plans include the Cape and Colorado. Perhaps, we can greet some classmates. Please send along any news — I am most willing to put it in the column. — **Robert Vegeler**, Secretary, Kennerk, Dumas, Burke & Baeks, 2120 Fort Wayne National Bank Bldg., Fort Wayne, Ind. 46802

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The correspondence from our class seems to come in waves. I apologize for abbreviating some of your letters, but when one person writes a nice long letter, I usually receive three or four more like it for the same issue. I may keep the lengthy ones for times like these. **Gerald E. Loe** has been awarded first-year honors at the Harvard Business School.

Winter has arrived in Texas after a colorful fall. The hunting season has been unfruitful for me thus far, but I have been enjoying the country life and my law practice. Please write. — **Hal Moorman**, Secretary, P.O. Box 497, Brenham, Tex. 77833

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Apologies for the missing column last time, but I hadn't heard a single word from anyone. This time I'm doing a little better.

B. Anthony Isaac and **Alan B. Lefkof** have been awarded first-year honors at Harvard Business School. They are now in their second and final year of the M.B.A. program.

Bill Rowe has written, "I am enjoying my second year at the University of Wisconsin Medical School while doing some flying and singing in a 'Chamber Singers' choir on the side. All in all, it's a fine time, but I miss Boston — of course!"

And finally, **Paul J. Lemaire** let me know that he and Margo Kavanaugh were married on May 22, 1976 in Needham, Mass.

I really wish I had more to report. Why not let me know what's happening? — **Jennifer Gordon**, Secretary, 5 Centre St., Cambridge, Mass. 02139

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I spoke with **Erland Van Lidthe de Jeude** shortly after he got back from Teheran, Iran. He was there for an international free-style wrestling competition, the Aryamehr Cup. There he picked up a bronze medal and the "Teheran trots" (tourista) for his efforts, which assisted the U.S. in placing eighth out of 12 countries. He defeated Mongolia, Japan, Eygpt, and Iran. Defeating the Iranian heavyweight made him an instant celebrity, as it appears that wrestling is to Iran as football is to the U.S. This January he anticipates being in another international competition to be held in Tblisi, U.S.S.R., following which he will tour and wrestle in Bulgaria, Roumania, Hungary, and Poland. After finishing that his next major wrestling contest will be with the 'Tute, with whom he anticipates finishing this June.

I recently walked into **Jean Hunter** and **Tom Hirasuna** who were taking vacations in Cambridge. Jean is in Product Development with Proctor and Gamble in Cincinatti, and Tom is making nylon with Dupont in Delaware and is living in Maryland. I am eagerly awaiting a report from each of them on how civilization has advanced beyond the Greater Boston area. I hear there may be some as far south as New York! Anyone have any comments?

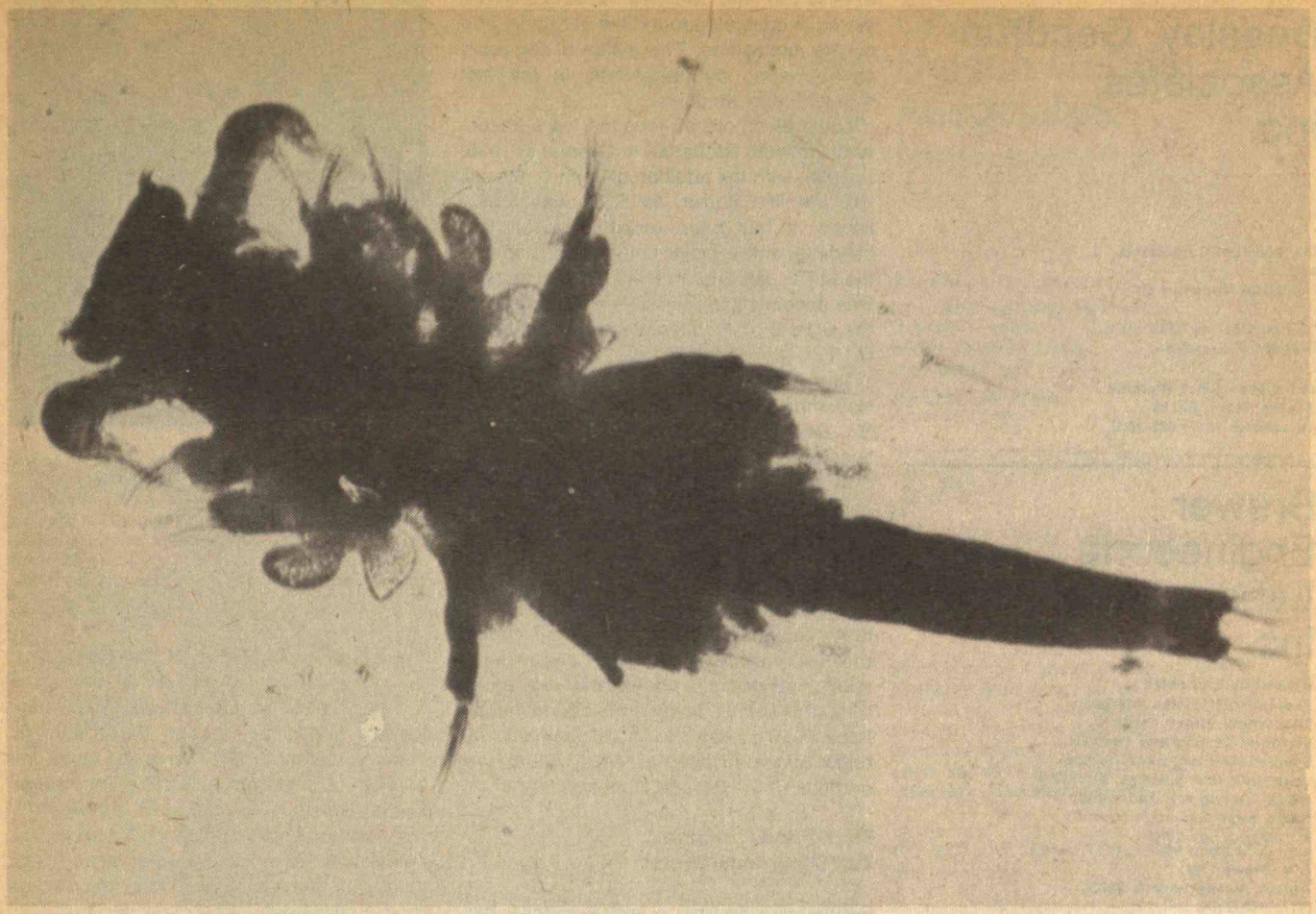
Mike Rabkin is a student at Duke Medical. He writes, "I have been working quite hard, much harder than ever before in my life. I have school for eight hours a day and must study about four hours a night and most of the day on weekends, so as you can guess I have my hands full. I really love medical school and this one in particular, although I sorely miss my friends in Cambridge and dispersed throughout the country. The other medical students here are generally quite nice, and unbelievably competent — I have never felt quite so pushed by a large group in my life."

Kevin Campbell is a student at the Sloan School and along with **Mark Crane**, is an intern in the Admissions Office. Kevin has hopes of getting on the ballot for Corporation membership as a representative of recent classes, and I hope he makes it. From Kevin I learned that **Jim Banks** is an electrical engineer with Hewlett-Packard in San Jose, California.

Did you know that two members of our class, **Larry Kernan** and **David Littleboy**, are tutors in East Campus? Each seems to be enjoying it.

My last bit of news is to report that **Barbara Miglierina** and **George Doerre** were married on October 16. They are living in Framingham now, with Barbara working as an engineer for GTE Sylvania in Needham, and with George working as an engineer for Data General in Southboro.

That is all for now. If this stuff seems to be a bit dated, it is due to the fact that these notes were due December 15. However, if you write to me it will make it into the notes. So, send me a letter and keep your secretary delerious with joy at getting mail. I do reply to all letters. — **Arthur J. Carp**, Secretary, 67 Badger Cir., Milton, Mass.



Elizabeth Frink, a foremost British sculptress, said he found "such hopeful talk about European unity an extraordinary event in our lives."

Shadow Photography: A Way to Study Small Biological Subjects

"You find that you are seeing more and more of less and less when you use the conventional microscope," says Harold E. "Doc" Edgerton, Sc.D. '31, Institute Professor Emeritus. (What he means is that the field of vision is extremely small and diminishes as magnification increases.) So he and Jeffrey Wilson, '75, developed a way to study biological subjects without using a microscope. They call it "shadow photography."

The method is simple; its basic element is a high-output, small light source, such as a small strobe lamp. This is positioned from one to two meters directly above a fine-grain film (Kodak Type 7302, for example) which is secured by a normal film holder placed on a table. An ultra-thin, clear plastic sheet placed over the film keeps it dry, and the photographic subjects are put directly on the plastic. (Shadow photographs have also been made with liquid in direct contact with the film, so large quantites of water can be quickly studied for biological material.) The almost parallel rays from the strobe throw the shadow of the object to be studied directly onto the film.

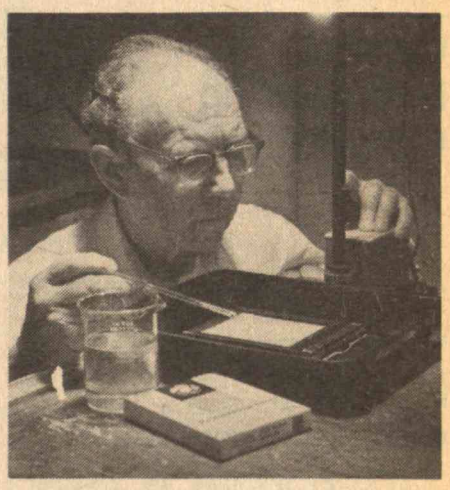
The advantages of this method of studying small objects are many: a larger area can be covered with great depth of field; live specimens can be studied in their natural environment (the electron microscope requires the subjects be in a vacuum, and thus dead); the silhouette system is completely free of chromatic or spherical distortions because no lenses are involved.

Successful enlargements of up to 100 times have been made without serious loss of detail, Dr. Edgerton and Mr. Wilson report, and higher magnifications are being tried.

New Louis Skidmore Room is Dedicated

A substantial portion of the Rotch Library visual collection (which numbers over 200,000 slides, photographs, prints, microforms, video tapes, motion pictures, drawings and plans) is now consolidated in the new Louis Skidmore room.

The room, on the third floor of Building 7, was made possible by a gift from the architectural firm of Skidmore, Owings and Merrill in memory of Louis Skidmore, '23, and designed by Lyndon Associates, Inc. (whose founder, Donlyn Lyndon, is an M.I.T. Professor of Architecture.) It utilizes efficiently a relatively small space, using suspended walls for display area and projection surfaces, and containing light tables, video, film and slide viewing equipment, and wall and free-standing display cases which



Developed by Professor Harold Edgerton, Sc.D. '31 and Jeffrey Wilson, '75, silhouette or shadow photography can produce well-defined images without the use of a microscope. An example is the brine shrimp (top), originally one milimeter long. The subject is placed in direct contact with a piece of fine grain film and a small strobe lamp, one meter directly above the film, is flashed to expose the film and capture the silhouette of the objects. Dr. Edgerton (above) is developing an exposure with a stroboscope as the light source.

extend out into the hall. Collections are stored in cabinets around the periphery and on the mezzanine. The inside of the room can be seen by passers-by in the hall through large windows.

Louis Skidmore co-founded his architectural firm with Nathaniel A. Owings in 1936. In 1939, with the addition of John O. Merrill, '19, the firm known as SOM was established. It has been responsible for nine buildings and a major library renovation on the M.I.T. campus. In 1940 Louis Skidmore was appointed to the Visiting Committee of the School of Architecture and Planning at M.I.T.

The dedication ceremony, held November 19, was attended by members of Mr. Skidmore's family and by representatives of the Council for the Arts, the School of Architecture and Planning, the Libraries and the M.I.T. administration.

During the ceremony, presided over by Walter A. Rosenblith, M.I.T. Provost, Louis Skidmore, Jr., spoke of his father's firm and its survival through the depression years. In that difficult time SOM always maintained the excellence of design, encouraged young designers, and expanded services offered to clients, he said. He added that his father would wish the room named in his honor to be dedicated as well to future generations of faculty and students at M.I.T.

From Kendal Square To "Cambridge Center"?

For nearly a decade — ever since N.A.S.A. abandoned its plans for a major electronics research and development laboratory in the Kendall Square urban renewal area northeast of M.I.T. — the land has been idle: 24 acres of dusty gravel, ragweed, and catch-as-catch-can parking just ten minutes by subway from downtown Boston.

Shall it be low-cost housing (Cambridge needs more of it)? Light industry to employ blue-collar workers (Cambridge has an unemployment problem)? Offices and research (Cambridge needs property tax income) relating to M.I.T., Technology Square, and the D.O.T.'s Transportation Systems Center?

After an intensive five-day review of these and other alternatives, a team of experts from the Urban Land Institute has opted for the latter. "Cambridge Center" would have 275,000 square feet of space for research and development, 500,000 square feet for offices (general and technical), 50,000 square feet for retail shopping, and a 200 to 300 room "economy" ($20 to $30 per room) hotel. It would create some 4,000 new jobs and "significant" tax income for the city, said the Urban Land Institute team.

James L. Sullivan, Cambridge City Manager, said the Urban Land Institute report was "the kind of real world test we've been waiting for." He seemed to be agreeing with Patrick Cusick, Jr., a real estate development expert from Bloomfield, Conn., who concluded, "It's time for Cambridge to move" when he finished his part of the U.L.I.'s survey.

What's wrong with his style? Almost everything — but that's the point. It's a clowned dive by Victor Rhoads, '79, for the benefit of students in Charles E. Miller's strobe photography class, and the whole episode was staged to attract registration for the Spring Term. Mr. Rhoads escaped without injury.

"Videocube" Between TV and Game

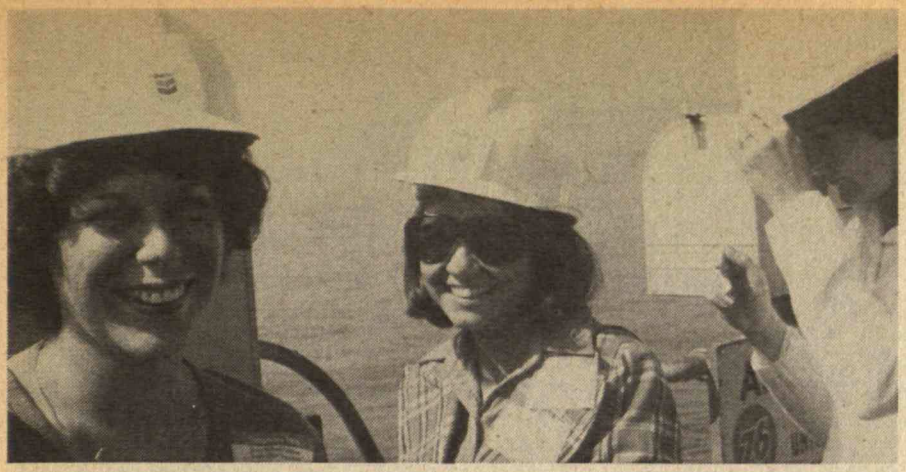
A "black box" to go between your customer's television set and the electronic game you want to sell him is the latest invention of students in M.I.T.'s Innovation Center (*see July/August, 1976, pp. 89-90*). It's a spin-off of the commercially successful Television Tennis game (the game itself plugs into home television sets) invented at the Center late in 1975.

The "Videocube," called an "electronic missing link" for the television game industry, is an arrangement of common electronic components — a radio-frequency oscillator, modulator, and selection switch which allows an easy interface between the radio-frequency circuits of a television set and a standard digital logic device.

The Innovation Center has applied for a patent and is seeking a licensing arrangement, according to Lamar Washington, Jr., '56, General Manager of the Center's Innovation Co-op. Nearly 65,000 Television Tennis games — the first low-priced electronic game aimed at the home entertainment market — have been sold by an independent manufacturer under licensing arrangements with the Center.

Rocketing Upward

The M.I.T. Rocket Society, having won its second successive Mid-Atlantic Championship in Aberdeen, Md., last fall, is now "the team to beat" next spring. The Society defeated some 60 entries in Aberdeen, one of the year's two large rocket meets. Now everyone's waiting for the East Coast Regional Meet in April.



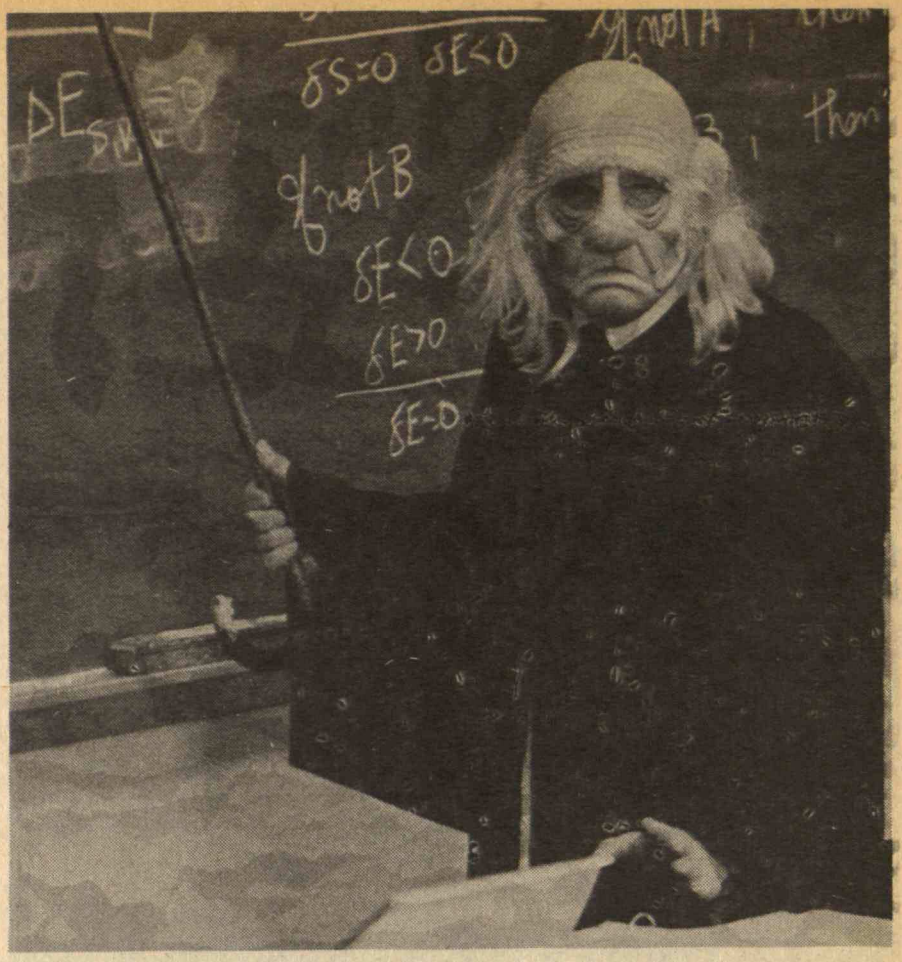
Spending the Day with Heidi

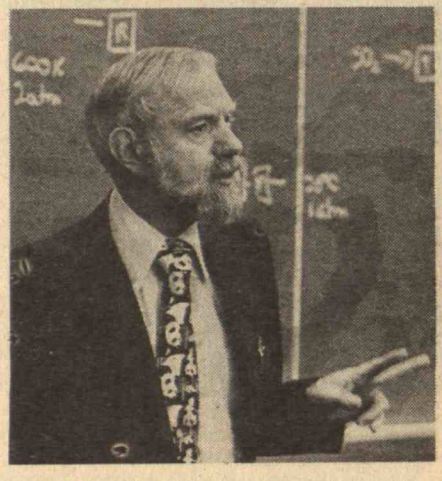
The amateur "hard-hats" in these pictures are M.I.T. alumni, members of the M.I.T. Club of Southern California and their guests visiting a platform known as Heidi operated by Standard Oil Company of California in 126 feet of water 1,000 yards offshore in the Santa Barbara Channel.

Heidi cost $5 million in 1967 and would cost five times as much today. The several wells beneath her tap a single pool of oil about 5,000 feet below the surface. Heidi's pumps bring up over 20,000 barrels of fluids a day from this mile-deep reservoir; 4,000 barrels of that is oil, and the rest is oil-contaminated salt water which must be treated before it can be returned to the sea.

That makes Heidi a "break-even" proposition but not a very successful investment, according to William Ryhert, Standard's Area Supervisor in Summerland, Calif., where Heidi's fluids are brought ashore. Standard would like to drill several more wells from Heidi to fully tap the reservoir beneath; unless permission for that is granted by the state, Heidi will probably be decommissioned and removed in another two years, when the production of oil will have declined.

The M.I.T. outing was arranged with Standard Oil by Rob Weadd, '36; Ray O. Wyland, Jr., '42, President of the Club, called it "the best tour and plant visit this group has ever had." — *J.M.*





Thermodynamics Pioneer Lives On In Annual Lecture

Once a year, the spirit of Josiah Willard Gibbs, a professor of mathematical physics who taught at Yale from 1871 until his death in 1903, lives on at M.I.T. — thanks to the inventive teaching of Professor Robert C. Reid, Sc.D. '54, in the Department of Chemical Engineering. Dressed in the academic robe common to Gibbs' time, Professor Reid teaches a class in Chemical Engineering Thermodynamics, subject 10.40, as he believes Professor Gibbs would have.

Why? Because Professor Gibbs "was really the first famous thermodynamicist," says Professor Reid. "He possessed great vision, but his work wasn't appreciated or understood in the U.S." until nearly the time of his death. Professor Reid uses this technique because "Gibbs represents a way of presenting scientific theory that is new to the students, he made heavy use of logic and less use of equations. Secondly, I try to deliver the lecture in the style of Gibbs' day, using primarily deductive proof. In the next day's lecture I explain and expand his work in more modern terms.

"Last, there is the point that his papers and theories written 100 years ago remain perfectly valid today."

Leaping the Great Wall

Vast geographical distance is the least of it. Culturally, socially, economically, and philosophically, the Chinese and Americans are poles apart. The National Academy of Science's Committee on Scholarly Communication with China is working to lessen this gap.

Frank Press, Professor of Geophysics and Head of the Department of Earth and Planetary Sciences, is Chairman of the Committee. He explained its evolution, concerns, and hopes to a Technology Studies Seminar this winter:

The Committee arranges communication with Chinese specialists, and about 250 Americans and 300 Chinese have participated since 1972. The committee sponsored about one fourth of all scholars who have gone to China and most of the Chinese who have come to the United States.

The Chinese visitors (mostly middle aged, some older, and a few, surprisingly young) are interested in a wide range of fields — computers, physics, lasers, petrochemicals, natural gas, industrial automation, basic research in biomedical science, tumor immunology, agriculture, to name a few. And they are prepared: they know where they want to go and who they want to see.

Although the Committee chooses delegations (there are five or six each year) and decides priorities, it is funded by private foundations, the National Science Foundation and the State Department, and the wheels are greased by diplomats. There is political motivation — the exchange is a symbol of political rapprochement between China and the U.S.

Culture Shock

Some problems are troubling.

Communication is painstakingly slow, with interpreters.

The culture shock is hard to ignore. The Chinese see the American scientist as an elitist, an individual working for himself.

The Chinese attitude toward research *is* totally different from ours: individuals minimize credit for their work; often the author of a paper is the name of a group.

Supposedly the government, the peasants and the scientists all contribute equally to discovery. The social point of view dictates: you can't set yourself above the peasant — he has an innate wisdom over the ages, and you must learn from it. "We're not interested in promotion or financial reward; we do things for the good of the country. You can't be so smart that someone you think is stupid couldn't make a discovery," they say.

There is no question that providing the "common man" with scientific literature is a good way to educate, says Professor Press. But it is wasteful for tens of thousands of individuals to generate useless data that is treated as useful. The Chinese are not rich enough to afford to support good and bad work side by side, he adds. They must put their resources behind good work.

Chinese Scholars are not Welcome

The Chinese are extremely selective of whom they admit. They are particularly disdainful of Chinese scholars, who ask how Chinese society works. But those Chinese scholars from America who have gained entrance have in fact been able to enrich the experience of the other American visitors by interpreting their specialized fields in the context of Chinese society. So the Committee has included Chinese scholars in their scientific delegations. In one instance the Chinese objected at first, and then agreed (when the Committee said if he didn't go, neither did the delegation). Their condition: that he be designated as an "interpreter." And it was assured he would have the same opportunities as the rest of the group.

When the Chinese come here, they send ahead a detailed itinerary of who and where they wish to visit, complete with names of people and laboratories. They want to see first hand what they read about. "Since we don't have as much information, we can't be as specific," says Professor Press. "So the American delegations must wait until they arrive in China, when the itinerary is announced. We would prefer to know in advance, so we can be sure that the plan is appealing to us."

On the best of the trips, the American delegations have had the same opportunities that the Chinese visitors to America have. "My delegation," says Professor Press, "learned an enormous amount in completely free, detailed communication."

But some people come back from China disappointed that they have not gained entry into Chinese laboratories of their choice. In one instance, the Chinese said they had made great strides in fighting a particular disease but wouldn't show the American medical delegation any patients.

These problems haven't dampened enthusiasm on both sides. Thousands of Americans request to see China first hand — Professor Press calls it "Chinamania." "We now have some idea of their accomplishments in a number of different fields, and our experience is disseminated through the whole scientific community by detailed published reports," he adds.

"You must Prepare Yourself . . ."

Imagine you are a participant. You will visit major institutes and see a lot of museums and factories (possibly too many). When you visit an institute or laboratory, you will listen to a series of lectures. Then perhaps there will be time for questions and dialogue.

But nothing will be familiar. One delegate describes the experience as like being catapulted out of one world and into another. "You must prepare yourself for a lecturer to get up and give you a five-minute lecture on political thought before he talks of his field," explains Professor Press. "You might think he does so out of obeisance or because there is an official in the room. But perhaps you are wrong; perhaps he sincerely feels Mao has purified his mind to enable him to do the research he is about to tell you about."

One-way Transfer?

Should we help the Chinese develop their science so that in 20 to 25 years they can contribute significantly in many fields? American industry would like access to Chinese markets, but some people fear (what they see as) a dangerous one-way transfer of technology from us to them. Said one American high-technology company official: "We're not going to give them material that enables them to compete in the world market if there is no reciprocation."

But Professor Press takes a more positive

Sitting in the middle of the stage of Avery Fisher Hall, blueprints in hand, Cyril M. Harris, Ph.D. '45, awaits the public's verdict on the $6.4 million reconstruction which he designed. Dr. Harris, who teaches electrical engineering at Columbia University, is considered by many to be the leading acoustician in the U.S., and his work on the symphonic auditorium in New York's Lincoln Center will apprarently secure that reputation: "a joyous place," says Avery Fisher, the philanthropist who funded the new work. (Photo: *The New York Times*)

view: the science exchange, although hardly more than "scientific tourism" now, is just beginning, there has already been significant progress, and its potential is tremendous. "We can now request itinerary changes in Peking and the Chinese honor them, and we've requested more intensive stays.

"We may not yet be involved in serious communication or joint research efforts, but we have enough of a glimpse to whet the appetite for the future." — *M.L.*

Acoustical Genius Transforms Avery Fisher Hall

Stand back — magician at work. Result: a new Avery Fisher Hall in New York's Lincoln Center. Acoustician in charge: Cyril M. Harris, Ph.D. '45, regarded by many as the leading acoustician in the country, carefully chosen by Lincoln Center's Board of Directors to do a job that has frustrated at least three predecessors.

The reconstruction of Fisher Hall, a 21-month, $6.4 million job, was not really magic at all. After much careful study of the old hall, which included listening from various seat locations while the New York Philharmonic rehearsed, Dr. Harris determined that only major surgery could cure the many faults which contributed to the poor quality of sound.

What were the complaints? Orchestra members said they could not hear one another, sometimes missing cues and guessing at entrances. The cellos and double basses had to "force" their instruments to balance the treble, because so much of the bass sound was lost. The audience heard only part of what was being played, and the sound tended to pour directly at them from the stage; in a good concert hall those listening have a sense of being immersed in music. Overall, Avery Fisher Hall was dry and lifeless, full of echos and dead spots.

What was Dr. Harris aiming for and how did he accomplish the desired effects?

Dr. Harris' goal was an "exciting" hall: live, reverberant, and full at every frequency with clarity and dynamic range from triple pianissimo to double forte, balanced with a powerful bass. A good hall is a "tight" hall, says Dr. Harris; the construction should be fortress-like with minimum sound escape through cracks and holes. (Sounds disappear soon enough through natural decay and absorption.) There should be a mixture of sound traps and barriers for even dispersion of sound, and a correct proportion of direct and reflected sound. Diffusing elements to assure even distribution and smooth decay of sound should be plentiful and of many sizes, so that as the sound bounces off the objects, it scatters evenly in all directions. Coffered, ornamented ceilings, crystal chandeliers, cornices, columns, statues, and even the heads of the audience can act as diffusers. (A hall sounds better when a concert is sold out.)

Before Dr. Harris arrived, Avery Fisher Hall was a modified curved fan, a series of sloping, converging lines, wide and high in back and tapered, the ceiling sloping down in flat steps, toward the stage. The curved shapes of the rear and side walls and of the side balconies presented concave surfaces that tended to scoop up the sound, concentrating it in certain areas at the expense of others, resulting in echos and dead spots. Even the floor (concrete) was sloped.

Dr. Harris concluded that only a radical renovation could solve the problem. So Avery Fisher Hall was stripped down to its steel-girder skeleton.

Typically a traditionalist, Harris avoided experimentation and used only time-tested principles and materials. Soundproofing was attained through the use of solid wood and heavy plaster — firmly secured — and heavy metal-gasketed doors with special sealing devices. A new floor was made of three-quarter-inch oak nailed to three-quarter-inch plywood mounted on wooden two-by-fours over masonry supports with a foot of air space underneath for flexibility to increase reverberation. Through this type floor the audience feels the music with their feet as well as hearing it. The stage, which was previously absorbing low-frequency bass tones, was given a similar floor, because much of the cellists' and bass players' sound is transmitted through the floor.

The ceiling, previously a series of smooth plywood surfaces which were too light in weight and absorbed some of the low frequencies, was reconstructed into a series of angled, stepped planes of random width and length, some three inches long for short-wavelength diffusion and some 12 feet for long-wavelength diffusion. The balcony fronts are now convex (instead of concave) to help scatter the sound. Rows of light globes arranged on the ceiling and the undersides of the boxes and balconies, sculptured surfaces of the ceiling, and irregularities of the side walls also contribute to proper scattering.

Other measures to reduce absorption include improved checking facilities to encourage the audience to check coats instead of holding them. (This explains why some halls sound better in the summer.) Non-absorptive low-pile carpeting is used only in the aisles. Air conditioning ducts are lined with sound-absorbing material to eliminate the audible whoosh of air entering the hall.

How does the new hall sound? Some say Dr. Harris has created a hall with the most detailed quality and clarity to be heard anywhere today. "I think you've added 20 years to my professional life," John Cerminaro, the principal horn player for the New York Philharmonic, told Dr. Harris after the first performance in the new hall, reports Bruce Bliven, Jr., in the *New Yorker*. "Now it's a joyous place; there's a sense of festival there," says Avery Fisher, the philanthropist whose bequest gave his name to the hall and made the reconstruction possible. — *Sandra Knight*

Individuals Noteworthy

Kudos: Honors, Awards, Citations

To **James B. Fisk,** '31, former president and board chairman of Bell Telephone Labs, the 1976 Hoover Medal for distinguished public service in engineering . . . to **Robert B. MacMullin,** '19, Associate Emeritus of R. B. MacMullin Assoc., the Electrochemical Society National Medal and Citation for 1976 . . . to **Ashok B. Boghani,** '71, Program Manager at Foster-Miller Associates in Waltham, Mass., the N.A.S.A. Certificate of Recognition for research in air cushion landing systems . . . to **David H. Howells,** S.M. '55, Professor Emeritus of North Carolina State University, the U.S. Department of Interior's Conservation Service Citation . . . to **Bernhard Schondorff,** '37, the Bundesverdienstkreuz am Bande, presented by the President of West Germany.

To **Rudolf E. Kalman,** '53, Director of the University of Florida's Center for Mathematical System Theory, the Oldenburger Medal from the American Society of Mechanical Engineers . . . to **Po-Chiu Mar,** '65, Representative director of AMF K.K. in Yokohama, Japan, a company citation for maintaining excellent control of bowling receivables in Japan . . . to **Reynold Lewke,** '76, and **Richard Balfour,** S.M. '76, the McGill Law Faculty's National Program Scholarship for 1976-77 . . . to **Robert A. McClatchey,** '60, Optical Physics Division of the Air Force Geophysics Laboratory at Hanscom A.F.B., Mass., the 1976 Guenter Loeser Memorial Award . . . to **J. William Gadzuk,** '63, staff scientist in the Optical Physics Division of the National Bureau of Standards, the Department of Commerce's Silver Medal Award.

To **Richard H. G. Cunningham,** '67, assistant legal officer with the 399th Civil Affairs Group of the Army Reserve, the Army Reserve Components Achievement Medal . . . to **William P. Kimball,** '31, Professor Emeritus of Civil Engineering at the Thayer School of Engineering of Dartmouth College, the Linton E. Grinter Award from the Engineers' Council for Professional Development . . . to **Richard Scranton,** S.M. '68, Assistant Professor of Civil Engineering at Northeastern University, the 1976 Edmund Friedman Young Engineer Award from the American Society of Civil Engineers . . . to **Kenneth J. Germeshausen,** '31, former President and Chairman of the Board of Directors of E. G. & G., an Honorary Doctor of Science degree from Franklin Pierce College . . . to **Joseph I. Goldstein,** '60, Professor of Metallurgy and Materials Science at Lehigh University, the Theodore L. Diamond Distinguished Professorship in Metallurgy.

Honors to M.I.T. Faculty

To **Morris Cohen,** '33, Institute Professor and Professor of Materials Science and Engineering, the 1976 William Procter Prize by the Scientific Research Society of North America . . . to **Norman C. Rasmussen,** Ph.D. '56, Head of the Department of Nuclear Engineering, the Distinguished Service Award of the U.S. Nuclear Regulatory Commission . . . to **David M. Epstein,** Conductor of the M.I.T. Symphony Orchestra and Professor of Music in the Department of Humanities, a 1976-77 award from the American Society of Composers, Authors and Publishers (ASCAP) . . . to **Christopher Walsh,** Associate Professor of Chemistry and Biology in the Department of Biology, the award of Dreyfus Teacher-Scholar.

To **Nevin S. Scrimshaw,** Institute Professor and head of the Department of Nutrition and Food Science, the Franklin Institute's first Bolton L. Corson Medal for his discovery of new and novel protein sources . . . to **Ali S. Argon,** Professor of Mechanical Engineering, the Charles Russ Richards Memorial Award by the American Society of Mechanical Engineers and Pi Tau Sigma . . . to **Rene H. Miller,** Head of the Department of Aeronautics and Astronautics, the I.B. Laskowitz Award for Research in Aerospace Engineering Sciences, Support Systems, and Components . . . to **Bruno Rossi,** Institute Professor Emeritus, the 1976 Rumford Premium from the American Academy of Arts and Sciences.

Fellows

George I. Gahm, '34, staff physician at Boston State Hospital, was elected a fellow in the American Psychiatric Association . . . **Arthur M. Poskanzer,** Ph.D. '57, senior chemist at the Lawrence Berkeley Lab, was elected a fellow of the American Physical Society. . . . **Richard T. Roca,** S.M. '72, a supervisor at Bell Labs in Holmdel, N.J., has been chosen as a Congressional Fellow for 1977 by the American Society of Mechanical Engineers. . . . **Herbert H. Richardson,** '53, Professor of Mechanical Engineering and Head of the Department of Mechanical Engineering at M.I.T., has been elected a Fellow of the A.S.M.E.

Deceased

Arthur H. Howland, '05; October 8, 1976; 894 Grove St., Framingham, Mass.
Nathaniel White, '06; May 4, 1976; 210 North Jefferson Ave., Wenonah, N.J.
Alan F. Edge, '08; November 2, 1975; 9 Brown St., Flemington, N.J.
Frank W. Sharmon, '08; October 11, 1976; Tucson, Ariz.
Stanley P. Finch, '09; January 7, 1972; 3312 Duval St., Austin, Tex.
Henry K. Spencer, '09; October 31, 1976; 1 Central Green, Winchester, Mass.
Herman C. Schmidt, '10; March 24, 1976; P.O. Box 1-G, Richmond, Va.
George A. Robinson, '12; August 3, 1976; 1001 Spring St., Silver Spring, Md.
Julius M. Rosenberg, '12; June 8, 1976; 615 Laurel Ln., Lakeland, Fla.
Raymond H. Walcott, '15; September 17,

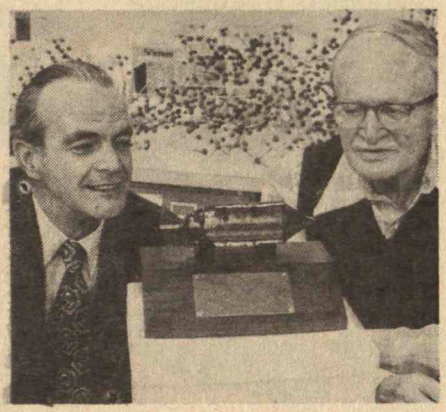
1976; 12 Berkeley Pl., Cranford, N.J.
Samuel L. Kuhn, '17; October 26, 1976; 23 East 74th St., New York, N.Y.
J. Raymond Ramsey, '17; October 11, 1976; 511 Spruce St., Plainfield, Ind.
Walter S. Frazier, '18; April 30, 1976; 223 E. State St.; Geneva, Ill.
Harry C. LeVine, '18; November 12, 1976; Chateau La Jolla, 233 Prospect St., La Jolla, Calif.
Wendell P. Monroe, '18; March, 1976; 7724 Beland Ave., Los Angeles, Calif.
Theodore Shedlowsky, '19; November 5, 1976; 419 W. 118 St., New York, N.Y.
John W. Barriger III, '21; December 9, 1976; 15 Washington Terr., St. Louis, Mo.
Wolfe W. Brown, '21; November 14, 1976; 14101 Drexmore Rd., Cleveland, Ohio
Donald S. Cheney, '21; June 28, 1976; 345 Kennard Rd. #2B, Manchester, N.H.
Norman Insley, '21; August 20, 1976; 36 Old Middletown Rd., Nanuet, N.Y.
Rupert S. Carven, '22; November 4, 1976; 109 Jericho Rd., Weston, Maine
Paul N. Hillard, '22; September 29, 1976; 1706 Belleair Forest Dr., Apt. 140, Clearwater, Fla.
Harry L. Pearson, '22; August 15, 1976; 35 Sterncrest Dr., Moreland Hills, Ohio
Nathan H. Weed, Jr., '22; November 1, 1975; 43 Thomas Sumpter Rd., Lady's Island, Beaufort, S.C.
John J. Gray, '23; May 24, 1976; R.D. 4, Box 364, Easton, Md.
Alvin J. Sadow, '23; September 30, 1976; 15 Sharpe Rd., Newton Center, Mass.
John W. Sands, '23; May 13, 1976; 665 Quincy Way, Hayward, Calif.
John H. Harding, '27; October 23, 1976
Leland G. Ruddell, '27; October 13, 1976; 625 W. Vine St., Springfield, Ill.
John L. Barnes, '28; October 1, 1976; 14710 Mulholland Dr., Los Angeles, Calif.
Louis C. Miller, '28; October 3, 1976; 8159 Presidio Dr., Cupertino, Calif.
Walter H. Ridley, '28; April 11, 1976; Carolina Village #15, 600 Lakewood Rd., Hendersonville, N.C.
Walter W. Schormann, '29; September 2, 1976; 182 Ashland Rd., Summit, N.J.
Harold D. Fine, '30; July, 1974; 2088 Washington St., Newton Lower Falls, Mass.
John A. Garcia, '30; August 8, 1976; P.O. Box 652, Spruce Pine, N.C.
George W. Gassett, '30; December 3, 1976; 31 Liberty Pole Rd., Hingham, Mass.
Alan Intriligator, '30; October 11, 1976; 21 Virginia Ave., Freeport, N.Y.
Thomas F. Litaker, '31; September 25, 1976; 3913 Gail St., Honolulu, Hawaii
Howard F. Atwood, '32; April 30, 1976; 279 High St., Topsfield, Mass.
Henry J. Koonce, '33; November 11, 1976; 1512 Country Line Rd., P.O. Box 771, Bryn Mawr, Penn.
Lewis H. Finneburgh, Jr., '35; October 3, 1976; 23305 Chagrin Blvd., Apt. 411, Cleveland, Ohio
Lucius Packard, '35; December 5, 1976; Box 203, Melvin Village, N.H.
Frederick A. Davisson, '36; March 23, 1976; 420 N.E. 155th Terr., Miami, Fla.
Joseph J. Egan, '37; April 13, 1976; 47 Chestnut St., Marblehead, Mass.
Robert L. Johnson, '37; April, 1976; 353 East Ave., Point Pleasant Beach, N.J.
Rudolf Vogel, '38; June, 1976; 1140 Laurel Ave., Bridgeport, Conn.
Samuel Silver, '40; November 5, 1976; 2613 Saklan Indian Dr., Walnut Creek, Calif.
Charles F. Glore, '43; April 1, 1976; 20 Stonegate, Lake Forest, Ill.
Dennis H. Groome, Jr., '44; July 22, 1976; 440 Rosa Ave., Metaire, La.
Edwin S. Lawrence, '47; June 19, 1976; 8213 Brittany Ct., Pittsburgh, Penn.
Paul E. Shea, '48; June 24, 1976; 10151 Pharlap Dr., Cupertino, Calif.
William H. Gehl, '49; September 1, 1976; 20 North Merrill Ave., Park Ridge, Ill.
Gordon Phillips, '49; October 14, 1976; 80 Culloden Park, San Rafael, Calif.
Claude J. Pasquier, '50; July, 1976; 257 Berrywood Rd., Severna Park, Md.
Peter Y. Ritner, '50; October 28, 1976; 340 Riverside Dr., New York, N.Y.
John J. Weaver, '50; November 15, 1976; 23 Hilltop Dr., Bedford, Mass.
Maurice A. St. John, '57; December 8, 1976; 167 Minuteman Dr., Concord, Mass.
Thomas C. Parker, '59; June 7, 1976; R.F.D. 2, Brush Hill Rd., Old Lyme, Conn.

I
Civil Engineering

With the Alumni

James O. Gruber, S.M. '75, has been appointed Town Projects Engineer of Arlington, Mass. . . . **Abraham J. Rokach,** S.M. '70, has joined the Chicago office of Skidmore, Owings and Merrill as a Senior Structural Engineer . . . **David H. Howells,** S.M. '55, retired as Director of Water Resources Research Institute of the University of North Carolina in October and was awarded the Interior Department Conservation Service Citation last December for his work as director of the Institute. He is now Professor Emeritus at North Carolina State University. . . . **Richard Scranton,** S.M. '68, Assistant Professor of Civil Engineering at Northeastern University, has been awarded the 1976 Edmund Friedman Young Engineer Award for Professional Achievement from the American Society of Civil Engineers. . . . **Brian Schultz,** S.M. '66, is a project engineer for Stone and Webster's Nuclear Power Plant.

The use of centrifuges have had a varied history, not only in testing soils and engineering models, but also in medicine — from the treatment of the mentally ill in the 19th century to a method of facilitating birth in 1965 — relates **Ronald F. Scott,** S.M. '53, in his article "Centrifuges in the Earth Sciences: A Revolutionary Idea" in the October/November issue of *Engineering and Science.*



When the Materials Research Society established a new prize for "contributions to the advancement of interdisciplinary materials research," it named the award for Professor Arthur R. von Hippel, who taught at M.I.T. from 1936 until his retirement in 1964 and was founding Director of the Insulation Research Laboratory in 1939. Now the Society — its President this year is Harry C. Gatos, Professor of Molecular Engineering and of Electronic Materials — has chosen Professor von Hippel (right) for its first award. The picture shows the two principals — Professor Gatos on the left — admiring the large ruby crystal which signifies the prize; Professor von Hippel also received a $1,000 honorarium.

II
Mechanical Engineering

With the Alumni

Thomas B. Sheridan, Sc.D. '59, Professor in the Department of Mechanical Engineering at M.I.T., is co-editor of the recently published book, *Monitoring Behavior and Supervisory Control. . .* **Wen-Li Wu,** S.M. '72, has been promoted to research specialist in Nylon Research at Monsanto Textiles Co. . . . **Richard T. Roca,** S.M. '72, a supervisor at Bell Laboratories, has been chosen as one of two Congressional Fellows sponsored by The American Society of Mechanical Engineers for 1977 . . . **John O. Outwater,** Sc.D. '50, was awarded a Ph.D. by Cambridge University in October; Dr. Outwater is professor of Mechanical Engineering at the University of Vermont . . . **Robert H. Cannon, Jr.,** Sc.D. '50, is the author of "Smart Energy, A Key Role for Computers" in the October/November issue of *Engineering and Science* . . . **Joseph Kho Ting,** S.M. '74, is working on the Rolls-Royce Combustion Development Program and the Westinghouse Combustion Development Program at Nemo Briar Ltd., Hull, Canada.

III
Materials Science

Professor **Julian Szekely** is the author of two recently published books: *The Future of the World's Steel Industry,* an edited collection of papers, and *Gas-Solid Reactions.*

With the Alumni

Jack H. Westbrook, Sc.D. '49, of the General Electric Research and Development Center, has been named the 1976 Campbell Memorial Lecturer by the American Society for Metals. His lecture, "Intermetallic Compounds: Their Past and Promise," was presented at A.S.M.'s annual meeting last October.

Richard W. Hertzberg, S.M. '61, Professor of Metallurgy and Materials Science at Lehigh University, is the author of the advanced college text, *Deformation and Fracture Mechanics of Engineering Materials.*

Being "In at the Beginning" of Physics as Applied Science

Philip M. Morse was attracted to science almost from the beginning. He remembers experimenting with chemicals at home — including drying gunpowder over a Bunsen burner — and his frustrations with high school chemistry: "Isolated facts didn't interest me much; patterns in fact were what excited me."

He also remembers that, as a grade school student, this interest in patterns gave him moments of depression. When science was presented this way in the early 1900s it seemed to be a complete whole, and "I began to be afraid that everything in science had already been discovered."

The same flame was still burning 20 years later, however. Soon after coming to M.I.T. from Princeton with President Karl T. Compton, Professor Morse realized that "I simply could not keep pointed in only one direction." So the groundword was laid for a career in applied physics — first in acoustics, then in the analytical, computer-based approaches which characterize what is now called "operations research." Indeed, one of Professor Morse's mission as President of the American Physical Society in 1972 was to emphasize the practical side of the profession: "I tried to point out that the physicist's training is that of a scientific generalist," he writes; "that there were many technical jobs they could do well . . . (including contributions) in important ways to the problems of energy and food and pollution they orated so vehemently about."

All this is in Professor Morse's autobiography — *In at the Beginning* — published recently ($15.95) by the M.I.T. Press. It is record of a career — more than 30 years of it spent as a member of the M.I.T. Physics Department faculty — which Professor Morse describes as having been "at the second, rather than at the top, level." So, he says, he has been able to see "the inevitable contrast between what the decision-makers thought they ordered and what actually took place." And he has studied with special interest "the links coupling basic research and final application — links that must be more generally understood if we are to avoid . . . gross misapplications."


5 Kg

Three Bell Telephone Laboratories scientists — Hargovind Vazirani, Harold Schonhorn, and Charles R. Kurkjian, Sc.D. '55 — dramatize their new development — a method for making extra-strong, extra-long glass fibers which "show promise as a major advance in 'lightwave' communications."

Glass Made Strong and Long

Charles R. Kurkjian, Sc.D. '55, is one of two principal investigators whose work at Bell Telephone Laboratories, Inc., has resulted in a new form of hair-thin glass fibers with breaking strengths of 600,000 pounds per square inch.

The new fibers can be manufactured in kilometer lengths, and they will be significant tools in the Bell System's plans to use glass fibers — "lightguides" — for transmitting telephone calls, computer data, and video signals. Their high strength indicates that long lengths could be manufactured reliably with little probability of breakage — an improvement which could reduce the cost of "lightguides," says Bell Labs.

Dr. Kurkjian and his coworkers — notably Harold Schonhorn — set out to reduce the size of flaws in the surface of glass fibers; it is the flaws that lead to points of stress and breakage. The new material is made by removing surface defects with an oxyhydrogen torch; the glass rod is then softened by heating in a focused laser beam and coated with an organic resin as protection.

VI
Electrical Engineering

Robert S. Cooper, Director of N.A.S.A.'s Goddard Space Flight Center, who was Assistant Professor of Electrical Engineering at M.I.T. from 1958-65, has been elected a Fellow of the American Astronautical Society.

Professor **Murray Eden,** an expert in biomedical engineering pattern recognition by computers and cognitive information processes, will take a leave of absence from M.I.T. to be Chief of the Biomedical Engineering and Instrumentation Branch of the National Institutes of Health's Division of Research Services.

With the Alumni

Vincent P. Healey, S.M. '49, was General Chairman of EASCON 76, the Electronic and Aerospace Conference of the I.E.E.E., held during September in Arlington, Va. . . . **Ralph L. Keeney,** S.M. '69, has joined the San Francisco office of Woodward-Clyde Consultants, a multidisciplinary engineering firm providing geotechnical and environmental consulting services; he has also co-authored the book, *Decisions with Multiple Objectives: Preferences and Value Tradeoffs.* . . . **Graham Sterling,** '48, has been appointed Vice President of Planning and Control for Analog Devices, Norwood, Mass. . . . **Edward E. David, Jr.,** S.M. '47, Executive Vice President of Gould, Inc., of Rolling Meadows, Ill., was selected to be a member of President Ford's Committee on Science and Technology last October; he was also elected to President of the American Association for the Advancement of Science. . . **Gerald Tomanek,** '67, is General Manager of Time and Space Processing, Inc., Palo Alto, Calif. . . . **Dennis W. Ducsik,** '68, is Assistant Professor of Science, Technology and Society and Adjunct Professor of Geography at Clark University.

David Kleinman, Ph.D. '63, Associate Professor of Electrical Engineering and Computer Science at the University of Connecticut, is director of a research project which seeks to understand how a person tracks a moving target by eye and coordinates hand movements — supported by a $99,980 grant from the U.S. Air Force Office of Scientific Research . . . **Melvin J. Sallen,** S.M. '56, has been promoted to Group Vice President of Sales for Analog Devices . . . **Michael Hack,** Ph.D. '75, is in the computer science department at IBM's T.J. Wolson Research Center in Yorktown Heights, New York . . . **Avery Hevesh,** S.M. '63, is principal staff engineer in reliability design at Raytheon; he also teaches product assurance and reliability courses at Northeastern's center for continuing education and is chairman of the reliability division of the American Society for Quality Control.

VIII
Physics

Professor **George Bekefi** is the author of the book, *Principles of Laser Plasmas,* recently published by J. Wiley and Sons.

With the Alumni

David L. MacAdam, Ph.D. '36, former head of the Image Structure Laboratory of the Eastman Kodak Company, has been appointed to a part-time professorship in the Institute of Optics in the University of Rochester's College of Engineering and Applied Science.

Eric T. Clarke, Ph.D. '44, was honored last June by the U.S. Defense Civil Preparedness Agency for his technical skills and expertise that laid the foundation upon which our National Fallout Shelter Program was built.

X
Chemical Engineering

With the Alumni

Thomas H. Goodgame, Sc.D. '53, Director of Corporation Environmental Control for Whirlpool Corp., has been re-elected to the Board of Directors of Sigma Xi, the Scientific Research Society of North America . . . **Robert C. Reid,** Sc.D. '54, Professor of Chemical Engineering at M.I.T., is the recipient of the Warren K. Lewis Award for Contributions to Chemical Engineering Education by the American Institute of Chemical Engineers . . . **Norman W. Boe,** S.M. '70, has been promoted to senior specialist in the Nylon Carpet Development Group of Monsanto Textiles Co. . . . **James C. Bresee,** Sc.D. '53, has been named Director of the Division of Geothermal Energy for the Energy Research and Development Administration . . . **Philip R. Sayre,** '54, is executive Vice President for the Sprague Meter Division of Textron Inc., Bridgeport, Conn. . . . **Robert P. Merrill,** Sc.D. '64, Vice Chairman of the Department of Chemical Engineering at the University of California at Berkeley, was selected for the Herbert Fisk Johnson Professorship of Industrial Chemistry in Cornell University's School of Chemical Engineering.

Robert W. King, S.M. '42, who has been Senior Vice President of the Linde Division of Union Carbide Corp., is now Director of Corporate Development . . . **T. H. Pigford,** '48, has been elected to membership in the National Academy of Engineering . . . **William P. White,** S.M. '63, has developed a woodburning conversion unit for oil furnaces and he explains how to do it yourself in his book, *Convert Your Oil Furnace to Wood,* published by his own company, The Firebuilders, Brooklyn, Conn.

Bowing to the applause of the Swedish royal family and audience, Dr. Samuel C. C. Ting, co-winner of the 1976 Nobel Prize in Physics, accepts the award in ceremonies in the Concert Hall in Stockholm, Sweden, on December 10. At the right are Sweden's King Carl Gustaf (left) with Prince Bertil and Queen Silvia. Dr. Ting, who is Professor of Physics at M.I.T., shared the award with Professor Burton Richter, '52, of Stanford University; they were honored for their simultaneous discoveries of what Dr. Ting calls the "J" particle, a new elementary subnuclear unit of matter. (Photo: Wide World)

Bicentennial Lectures: World Change and World Security

Science and technology have accelerated change in developing nations in the past two decades, bringing heightened expectations and the formation of numerous independent nations. But no policies have emerged to reconcile the aims of individual nations with the larger need for world security. A Bicentennial Lecture Series, World Change and World Security, will bring world leaders to M.I.T. "to stimulate thought about practical initiatives which nations might take, individually and collectively, to gain better control of our dynamic world." All the lectures will begin at 8 pm in Kresge Auditorium.

March 9
Willy Brandt
Chairman of the Social Democratic Party of Germany and President of Socialists International (Geneva)

March 15
McGeorge Bundy
President of the Ford Foundation

March 21
David A. Hamburg
President of the Institute of Medicine of the U.S. National Academy of Sciences

March 24
Sigvard Eklund
Director General of the International Atomic Energy Agency

April 4
Roberto de Oliveira Campos
Brazilian Ambassador to Great Britain

April 20
Robert S. McNamara
President of the World Bank

XI
Urban Studies

Professor **Martin Rein** is the author of the book, *Social Science Public Policy*, recently published by Penguin Books.

Two individuals from the M.I.T. Community Fellows Program were members of President Carter's transition team: **Benjamin Brown,** a Fellow in 1971-72, a state representative from Atlanta, Ga., and a deputy campaign manager for Carter; **Larry Bailey,** former assistant director of the U.S. Conference of Mayors, was scheduled to be a Community Fellow this academic year.

With the Alumni

William Roy Shapiro, M.C.P. '74, has completed a one-year term on a special civil investigatory grand jury which reported to the people of San Francisco on the performance of their city and county governments; he is now an urban planner working with programs for the elderly and former prison inmates and addicts. . . . **Gene Milgram,** M.C.P. '75, is a research officer for the Institute of Urban Studies at the University of Winnipeg, involved in housing rehabilitation and neighborhood preservation issues. He would like to see any M.I.T. friends who are "traveling through the Canadian prairies and stopping in Winnipeg." . . . **Louis Edward Alfeld,** M.C.P. '68, Director of the Department of Planning and Community Development in Marlborough, Mass., is a co-author of the textbook, *Introduction to Urban Dynamics,* published by Wright-Allen Press, Inc.

XIII
Ocean Engineering

Professor **J. Harvey Evans** has been awarded the Davidson Medal of the Society of Naval Architects and Marine Engineers; he was also named a fellow of the Society.

With the Alumni

Jerome A. Patterson, '45, has been named Assistant to the President of General Steel Co., a subsidiary of Howell Instruments, Inc. . . . **Mark R. Bebar,** S.M. '73, was married to Bonnie Kay Botton of Gladstone, Va., on June 5, 1976.

XIV
Economics

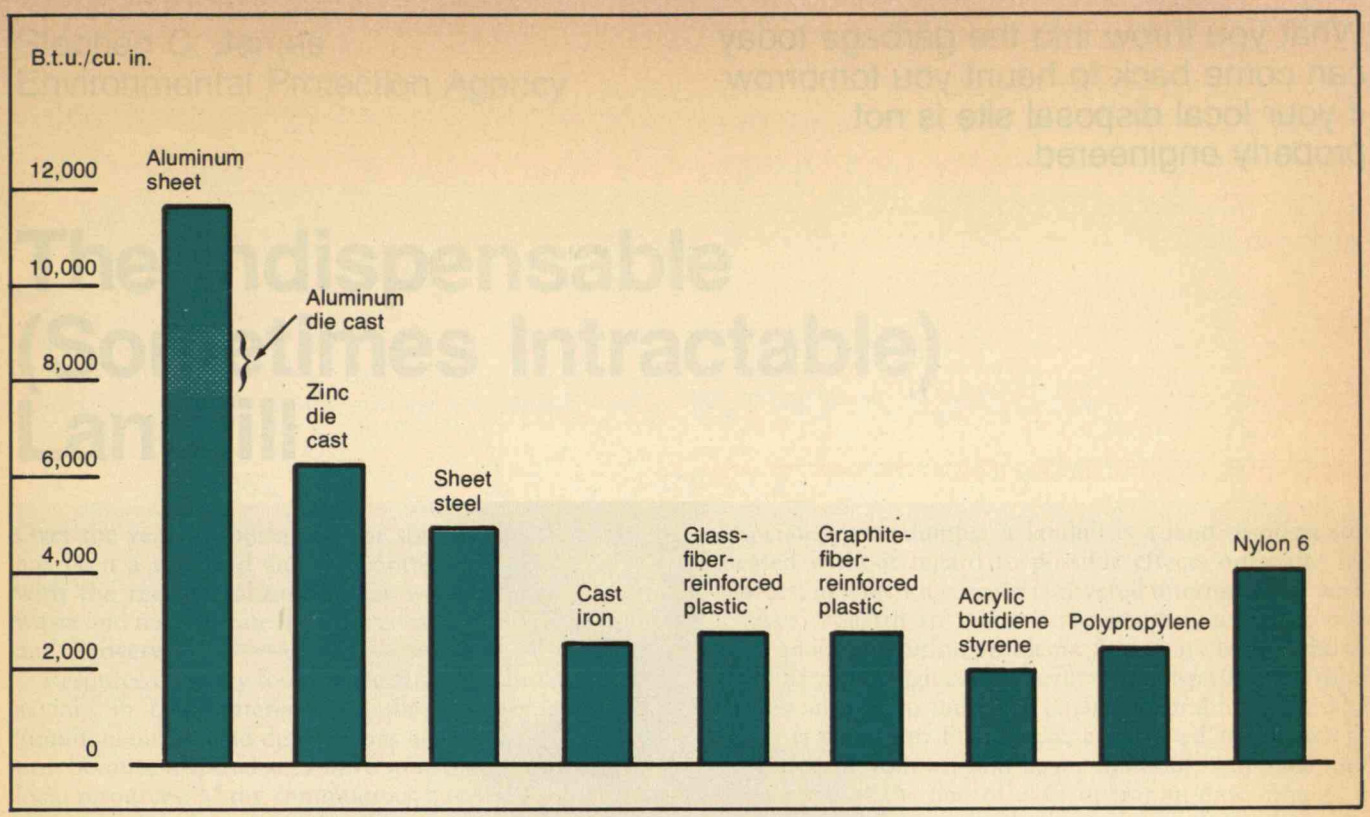
With the Alumni

Daniel H. Gray, Ph.D. '58, is Managing Director of The Berwick Group, management consultants, Belmont, Mass. . . . **Jaleel Anmad,** Ph.D. '65, is teaching at Concordia University in Montreal, Canada.

XV
Management

With the Alumni

Arthur Gerstenfeld, Ph.D. '66, Professor and Head of the Department of Management at Worcester Polytechnic Institute, is the author of the book, *Innovation: A Study of Technological Policy,* recently published by the University Press of America. . . . **Charles C. Joyce, Jr.,** '56, is an Associate Technical Director of the New Battlefield Systems Division at METREK of the MITRE Corp. . . . **Mark S. Plovnick,** S.M. '70, is Assistant Professor of Management at Clark University . . . **James G. Kaiser,** S.M. '73, is Manager of Special Projects at Sovirel, a subsidiary of Corning Glass Works in France . . . **Eph McLean,** Ph.D. '70, has been advanced to Associate Professor at the Graduate School of Management at U.C.L.A.; he is also co-author of the book, *Strategic Planning for M.I.S.* . . . **R. B. Gillett,** S.M. '52, is Research and Development Director for RJR Archer, Inc. . . . **David H. Campbell,** S.M. '68, has been named Division Vice President of Business and Planning Analysis for The Hertz Corp . . . **Samuel E. Bodily,** S.M. '74, is Assistant Professor of Management Science at the School of Management, Boston University . . . **Colby H. Chandler,** S.M. '63, has been named President of the Eastman Kodak Co. . . . **Markham I. Alpert,** '64, was promoted to Full Professor of Marketing at the University of Texas at Austin last September. . . . **Donald W. Male,** S.M. '58, has been elected to the Board of Trustees of the Unitarian Universalist Association . . . **Henry H. Perritt, Jr.,** '66, has joined Consolidated Rail Corp. as Assistant to the Chairman . . . **Kenneth R. Hootnick,** '61, is Operations Vice President and General Manager of the Diamond Division of General Cable Corp., Greenwich, Conn.



The energy required to produce a cubic inch of various metals and plastics. The chart shows that the use of plastics in the construction of automobiles would save energy, but so would the use of recycled materials.

volve only about a quarter of the total. Now the illustration on this page compares the energy required to produce a unit volume of a number of materials. It shows the favorable energy position of plastics as compared to other light-weight materials, but the important point here is that recycling of the junk car provides more than material resources. It also provides a significant conservation of energy. For aluminum and plastics as well as steel, the reuse of scrap saves much of the energy cost of virgin materials. Indeed, by adapting a calculation made by R. S. Berry and F. M. Fels, it can be estimated that under ideal circumstances a savings of 30 per cent of the total energy required for manufacturing cars is hypothetically possible.

Mining the Junk Car

The recycling of junk cars for scrap has tended to obey traditional market and economic forces. Supply and demand, scrap availability, and related factors have stimulated the development of new processes (such as the auto-shredder) and new technologies for improving the quality, availability, and economics of junk-car scrap. Current concerns about resource depletion will also help. However, there are many institutional, economic, and legal factors that currently inhibit the complete recovery of junk cars for recycling. Cumbersome vehicle "detitling" laws exist in various states; they make it difficult to collect and purchase junked or abandoned cars. Prevailing freight rate structures sometimes penalize the transportation of scrap and solid waste. These and other "disincentives" exist as obstacles to more efficient conservation practices. The automotive industry is working with state and local governments to resolve them.

In many respects, "mining the junk car" may be considered analogous to the mining of natural ore bodies. Indeed, many of the scrap processing and separation techniques bear close similarity to the processes traditionally associated with mining and primary metal processing. As the material content of the junk car changed (as does the content of an ore body) so new technologies for refining and concentration needed to be developed.

Recycling of the junk car represents a systems approach to resource recovery. Accordingly, the junk car can be viewed as a renewable resource system — a system which, because of its impact upon national material-use patterns, serves as a vital component of a national conservation effort. Its history, technological development, and response to market forces can provide lessons for the development of other solid-waste recovery systems.

Reference

Berry, R. S. and Fels, F. M., "The Energy Cost of Automobiles," Science and Public Affairs, p. 11, December, 1973.

Julius J. Harwood is Director — Materials Sciences, Engineering and Research Staff, Ford Motor Company. Before joining Ford in 1960, he was associated with the Office of Naval Research as Head of its Metallurgy Branch. Mr. Harwood has published over 70 articles in the fields of corrosion, high-temperature materials, materials resources, new materials development, and the management and planning of industrial research, and is the editor of five books on these topics. Among many professional activities, he is 1976 President of the Metallurgical Society of American Institute of Mining, Metallurgical, and Petroleum Engineers. This article is adapted from a paper prepared by Mr. Harwood and L. R. Mahoney for the symposium on Materials and the Development of Nations conducted by the National Academies of Science and of Engineering in April, 1976; it is published here by permission of the Academies and of Pergamon Press, Inc., in whose journal *Materials and Society* the original paper is appearing.

What you throw into the garbage today can come back to haunt you tomorrow if your local disposal site is not properly engineered.

An open-burning dump is the ultimate in poor solid waste management. It causes air and water pollution, and invites disease-carrying scavengers. With proper engineering, however, landfills can have minimal impacts on the environment. (All photographs courtesy of the E.P.A.)

Stephen C. James
Environmental Protection Agency

The Indispensable (Sometimes Intractable) Landfill

Over the years disposing of our solid wastes in landfills has been a standard and noncontroversial practice. But with the recent realization that we will always create waste and never create land has come a push for recycling and recovery.

Resource recovery looks quite attractive because of the savings in raw materials and the recovery of energy. Simultaneously, land disposal has acquired a bad reputation because disposal sites have sometimes contaminated local resources. Many communities have become wary of the concept of sanitary landfilling, refusing to allow landfills near them, and are looking for alternative methods, such as resource recovery, to ease the problem. As we shall see, however, landfills will always be with us. Resource recovery, although valuable, will never be the total answer. With the proper management, we can use both techniques to dispose of our wastes safely and efficiently.

How Big the Garbage Can?

It's obvious that we will always produce waste, but most people do not realize that we face a steadily growing production of solid waste. As you can see on page 46, by 1990, it is expected that solid wastes will increase by 23 per cent, even after resources are recovered. While resource recovery will keep the average per-person amount of waste stable, population growth will assure a boom in solid waste.

And these quantities do not include municipal sewage sludges from waste treatment plants, which will certainly increase considerably with the installation of advanced waste water treatment by communities. Nor do the figures include the amount of hazardous wastes which will require disposal. Present information indicates that 5.6 million dry tons of raw undigested, domestic, sewage sludge and 40 million metric tons of chemically, biologically or radioactively hazardous wastes are generated annually, presenting major problems in waste disposal.

A solid waste land disposal site may accept garbage, refuse, municipal and industrial sludges and liquid wastes, discarded solid materials resulting from agricultural, industrial, and commercial operations and from community activities, and hazardous wastes. It may be one of four types — a dump, a landfill, a sanitary landfill, or a secured landfill.

A dump is an uncovered land disposal site where solid and/or liquid wastes are deposited with little or no regard for pollution control or aesthetics. Open burning, scavengers, and disease-carrying organisms are problems associated with dumps. A landfill is a land disposal site located without regard to possible effects on water resources, in which the waste is covered intermittently with a layer of earth to minimize scavenger, aesthetic, disease, and air pollution problems. A sanitary landfill, however, uses an engineered method of disposing of solid wastes on land to minimize environmental hazards. The waste is spread in thin layers, compacted to the smallest practical volume, and cover material is applied and compacted at the end of each operating day. Finally, a secured landfill is a land disposal site that allows no hydraulic correction, segregates the waste from the environment using containers, etc., has restricted access, and is continually monitored.

The first three types of land disposal sites are intended to accept primarily municipal and commercial wastes, may or may not accept sewage sludge, and may accept hazardous wastes with or without the knowledge of the site operator. A secured landfill is designed to accept hazardous wastes and could be thought of as an environmentally secure underground storage basin.

Mini-Garbage

Such practices as burning wastes for energy, recycling and encouraging waste-reducing packaging in products (*see box p. 42*) will help minimize the volume of waste that needs ultimate disposal, besides yielding energy and a possible profit. But these methods may either require large capital costs or may be publically unacceptable because they are obtrusive additions to a community. Thus, any realistic waste management scheme must consider other standard processing methods currently available for volume reduction, including baling, shredding and incineration. These methods, by reducing volume, can extend the life of landfills and thus relieve the need for finding new locations for disposal sites.

Baling consists of compacting waste material into a rectangular shape and holding it in that shape with tie wires if compaction is not dense enough for self-holding. The typical bale is about three feet by three feet, with a variable length.

Baling will increase the life of a land disposal site because of the 30 to 50 per cent greater densities achieved by compaction with the baler (1,000 to 1,700 pounds per cubic yard, as compared to 600 to 800 pounds per cubic yard achieved by compacting with vehicles at the site). The comparative economics of municipal solid waste balers and conventional disposal are being examined at sites in Cobb County and Atlanta, Ga., and Omaha, Neb.

Water pollution hazards from landfill runoff are greatest where the rainfall is heaviest. Ironically, in the U.S. these are the same areas where the population is highest, and the landfills most numerous.

Density of solid waste can be increased from 25 to 60 per cent by shredding processes, which include pulverization, milling, hammermilling and grinding. Approximately 80 U.S. cities use shredders in recovery systems and in final disposal schemes.

Incineration, however, can produce an 80 to 90 per cent reduction of the total volume of municipal solid wastes. Only particulate matter carried by the gas stream, incinerator ash residue, grate siftings, and process water are left over for further processing or disposal. Conventional large refractory-lined incinerators and small modular incinerators are currently being used in municipal, commercial, and industrial facilities. Because of high capital and operating costs, stringent air pollution requirements, and the availability of other processing technologies, use of the large, conventional incinerator is on the decline, being replaced by smaller, modular units. Conventional incinerators process from 200 to 400 tons per day per furnace, have an operating cost of $10 to $20 per ton, and have difficulty meeting air pollution standards. Small modular incinerators, processing less than 50 tons per day, are increasingly popular in smaller communities, can recover energy from wastes, have an operation cost about the same as larger models, and can be put on line much sooner than conventional incinerators. Small, modular incinerators may also become popular in larger cities — with groups of four to eight incinerators placed throughout the community — because of the savings obtained by reduced transportation of unprocessed solid waste.

As all too many communities have learned, solid waste entombed in a landfill can easily return to haunt the disposer in the form of dangerous or unpleasant substances emanating from a landfill. The most common source of landfill problems stems from the generation of leachate caused by water percolating through the solid wastes. A portion of precipitation falling on a landfill infiltrates into the ground picking up soluble and suspended contaminants and forming a leachate which can enter bodies of water or contaminate nearby land. Leachate production from a landfill can be enormous if care is not taken in siting and engineering. For instance, in the worst case, a 50-acre open dump subjected to a one-inch rainfall can yield up to 1.36 million gallons of leachate.

The water for leachate formation and subsequent contamination can come directly from precipitation, from surface runoff from surrounding land, or from water entering through the sides or bottom of the landfill. Leachate formation can also result from moisture contained within solid or liquid wastes or moisture from solid waste decomposition.

However, because precipitation contributes the most to leachate formation, the potential water pollution problem from leachate is greatest where average annual precipitation exceeds the loss by soil evaporation or plant transpiration. Such areas are generally east of the Mississippi River and in the coastal region of the Pacific Northwest. About 70 per cent of the municipal landfills found in the United States are located in these water surplus areas. These are also areas of high industrial and residential density. Thus, many cities' local water resources are near areas where potential contamination from land disposal sites might occur.

Hazardous Leachate

Raw leachate contains many substances, primarily heavy metals, that are potential threats to human health. However, even though leachate heavy metal concentrations are in excess of E.P.A. drinking water standards, it is not clear how likely it would be for these recorded levels to be found in drinking water supplies or for contamination to reach the human body. Before leachate reaches an aquifer, it is subject to the purifying effect of the unsaturated zone around the landfill. And the usual odor and/or color of municipal leachate would immediately alert people not to use water contaminated by it.

But it is clear that if solid waste is placed directly into ground water, or if leachate is allowed to drain directly into surface water, it can severely damage the environment. It can destroy life in a water resource by coating the bottom sediment so that feeding by the animal population is precluded. Iron dissolved in leachate is especially effective in this coating. Toxic metals, such as selenium and mercury, can build up in the aquatic life and prevent their use by man.

Leachate materials which may not even be hazardous to man can still cause economic damage. For instance, while iron in leachate does not pose a health problem, it can prevent use of a water supply (public, private, or industrial) because of staining, taste, and odors which it imparts. This may lead to economic damage because alternative water resources must be sought.

For instance, the Llangollen, New Castle County, Delaware, landfill was operated from 1960 to 1968 in a worked-out sand and gravel pit. Breaks in the confining layer above the aquifer, either natural or man-made, allowed contamination of the ground water. To date at least ten residential wells, three industrial wells, and eight

Appliances and tires are among the widely varied types of wastes that landfills are expected to accept and dispose of efficiently and safely.

Stopping Waste Before it Starts

In the past, goods were generally produced without considering the environmental impacts of their discard. Likewise, solid waste management concentrated on disposing of discarded goods, rather than examining the system which produced them. Recently, however, the concept of waste reduction has sparked interest, focusing attention on the solid waste impacts of product manufacturing.

Waste reduction decreases the generation of solid waste by reducing the consumption of raw materials. Specifically, waste can be reduced by using less materials per product, increasing product lifetime, making products reusable, and by simply reducing the consumption of goods.

Although the environmental ethic has been partly responsible for the new emphasis on waste reduction, manufacturers have always been motivated to reduce wastes to hold down their operating costs. However, the recent rapid increase in energy costs and the threat of materials shortages have tended to inspire industry to greater consideration of waste reduction. Besides holding down costs, utilizing materials more efficiently can reduce the environmental and resource consumption impacts throughout the economic system from the time raw materials come out of the ground to the time the discarded product goes back in.

Public officials have become interested in waste reduction to help alleviate disposal problems. As Stephen James points out, landfills pose the hazard of water pollution from leachate; and incinerators and/or energy recovery systems cause varying amounts of air pollution. Reducing waste generation rates can also extend the useful life of a landfill, saving on disposal costs.

Some possibilities for reducing material use can offer impressive savings. For instance, about 25 to 30 per cent of the steel used to produce conventional three-piece cans could be saved by substituting the two-piece drawn-and-ironed manufacturing process. One problem with this substitution is that products not packaged under pressure fail to provide the internal force necessary for overall can strength. As a result, drawn-and-ironed cans have been primarily used for carbonated beverages. Even so, if this changeover had been made in 1973, about one million tons of steel would have been saved.

Milk currently comes in four major container sizes — gallons, half-gallons, quarts and half-pints. About 11 per cent of the milk sold is in half-pint cartons. To conserve materials one major carton manufacturer is now producing a half-pint milk carton, in which the base has been reduced from the standard 2.75-inch square to 2.25 inches. This redesigned container uses about 31 per cent less paper and 16 per cent less low-density polyethylene than the familiar half-pint carton. If all half-pint containers were made using this new design, about 59,000 tons of paper and 4,000 tons of polyethylene could be saved annually.

Materials consumption can also be reduced by increasing package size, thereby decreasing the ratio of package weight to volume of product contained. For example, 128 ounces of household bleach may be purchased in either one 128-ounce bottle or a combination of ten 12-ounce containers and one 8-ounce container. The amalgamation of smaller containers, however, requires 153 per cent more polyethylene than does the "giant economy size."

There are limitations to a policy of converting to larger sizes. Some products have limited shelf life and others may spoil quickly once the package has been opened. Also, many consumers have limited storage space, particularly for foods that must be refrigerated. Furthermore, the consumer may value the convenience of handling a smaller container.

Buying the "large economy size" of a product reduces solid waste because less container is needed per amount of product purchased.

The second option for waste reduction — longer product lifetime — can be achieved by either making products more durable or providing for their reuse. Appliances, for example, could be made to last longer. There is, however, still much to be learned about the reasons for appliance discard. The economic and technical tradeoffs between repairing an appliance and making the components last longer and the social effects of longer appliance lifetime need to be examined *(see "Making Products Live Longer," January, pp. 48-55).*

Product reuse can either be internal to an organization or outside the control of the organization. An example of internal use is the recovery and reuse of corrugated shipping containers used by furniture moving companies. Beverage container deposits which result in reuse or recycling are an example of external product reuse.

Broader laws regulating products and establishing fiscal measures are now being considered by Congress. A product regulation approach to waste reduction might involve setting certain minimum standards of environmental impact and resource consumption that a product would have to meet. In the fiscal area, legislators are studying mechanisms to incorporate the environmental costs of a product's disposal into its price. The product's price would then more nearly reflect its true cost to society as a whole. This would give consumers an economic incentive to purchase those goods that cause the minimum damage to the environment. — *Charles Peterson, E.P.A.*

Charles Peterson is an environmental protection specialist with the E.P.A.'s Office of Solid Waste. He received a B.S. in packaging from Michigan State University in 1970, and he is working toward an M.B.A. from George Washington University.

Bales of compacted solid waste are stacked in a landfill. Baling is one method for increasing the life of a landfill, because bales occupy less space than unbaled waste.

public supply wells have been threatened or damaged. The residential wells have been abandoned, and public water has been supplied. The industrial and public supply wells have been forced to reduce production, and counter-pumping wells have been installed to intercept leachate migration. These avoidance and corrective costs have amounted to $2 million thus far. Correction of the problem will require a minimum of $9.5 million to dig up and move the landfill or $15.3 million for continuance of counter pumping or hydrologic controls.

Stopping the Leachate

One way to prevent leachate generation and contaminant migration is to assure that landfill sites meet the proper soil and geologic requirements. Landfills should be located where there is suitable soil both for cover material and to contain leachate, preventing or limiting subsurface movement. While fine sands or clay may effectively limit the zone of contamination from a site, a coarse material such as gravel can allow an extensive zone of contamination. Cracks or fissures may allow migration and contamination over many thousands of feet. Synthetic liners have been used to build waste-water holding and treatment ponds, and these may also be used to line a landfill site. Materials, now used or proposed as landfill liners, include conventional paving asphalts, hot sprayed asphalt, polyethylene, polyvinyl chloride, butyl rubber, compacted clay, and mixtures of the native soil with either montmorillonite or cement. The two major problems with liners are cost — which can range from $0.72 to $3.42 per square yard — and the possibility of a liner being punctured during installation or initial filling. Leakage from such a puncture may not be detectable until many years later, when the damage has already been done. Liners are also used to cap or seal the top of the landfill site after completion to eliminate infiltration of water from above. Soil, capable of growing vegetation, should then be placed over the liner for protection. Even if a liner is used, there will still be some leachate, which must be collected and treated before being discharged. Currently the Environmental Protection Agency is investigating leachate treatment by spray-irrigation, activated sludge, and anaerobic filter.

Spray-irrigation involves spraying the leachate over the area around the landfill, and allowing various processes in the soil to render it harmless. These soil processes include dilution, filtration, sorption, chemical precipitation, and microbial activity. Spray-irrigation would be a favorable treatment method in rural areas because of low capital and operating costs. Spray-irrigation treatment of leachate is currently being investigated at Bluefield, W. Va., through an E.P.A. agreement with the Agricultural

Research Service. The study is currently investigating different loading rates on soils in that area.

Activated sludge treatment depends on the aerobic, microbial action on the incoming waste to reduce the organic strength of the leachate. The waste is pretreated to remove heavy metals which would inhibit bacterial action. Activated sludge systems can achieve a high degree of treatment but are expensive to construct and operate and generate sludge which must be disposed of by recycling back to the land disposal site. The current activated sludge treatment experiment at Tulleytown, Pa., sponsored by the E.P.A., has shown encouraging preliminary results.

The anaerobic filter for leachate treatment is a column filled with various types of solid media, which provide a great surface area on which anaerobic bacteria can grow. The wastes flow upward through the column, contacting the media, and are retained by the bacteria. The degree of treatment depends on the residency time of waste in the filter. The anaerobic filter is very promising because of low operating costs and low generation of sludge. An additional benefit of the anaerobic process is the generation of methane gas which can be burned to heat influent to the filter. The current E.P.A. project using the anaerobic filter in Enfield, Conn., will begin operation early this year.

The E.P.A. plans to complete its evaluation of these three methods by the end of 1978. Each method has pros and cons, and each would be suited for particular instances. Another method, which is not being currently investigated, is the addition of leachate to the sewer system. Seattle, Washington, and Redding, California, have reported favorable results in applying this treatment method. In general, the leachate becomes so diluted that its presence cannot be detected.

Industry	Wasteload (mm. metric ton, wet) 1974	1977	1983	Per cent managed off-site
Primary metals	20	21	25	2
Organic chemicals	7	12	13	20
Electroplating	5	4	5	70
Industrial inorganic chemicals	4	4	5	15
Textile mill products	2	2	1	5
Petroleum refining	1	1	1	60
7 others	1	2	2	75
Total	40	46	52	18

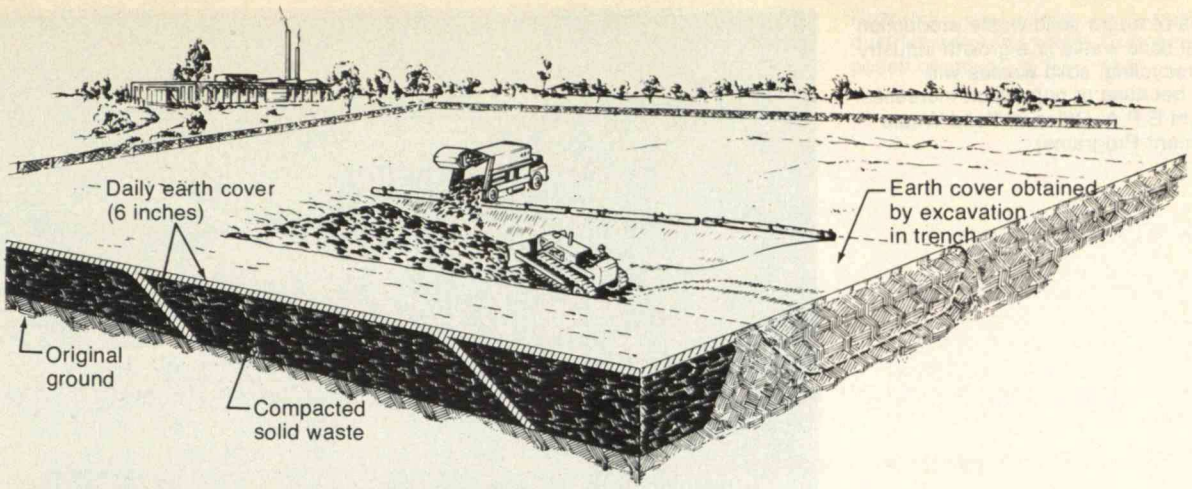
While some categories of hazardous wastes will decrease over the next decade or so, most will increase. (E.P.A. data)

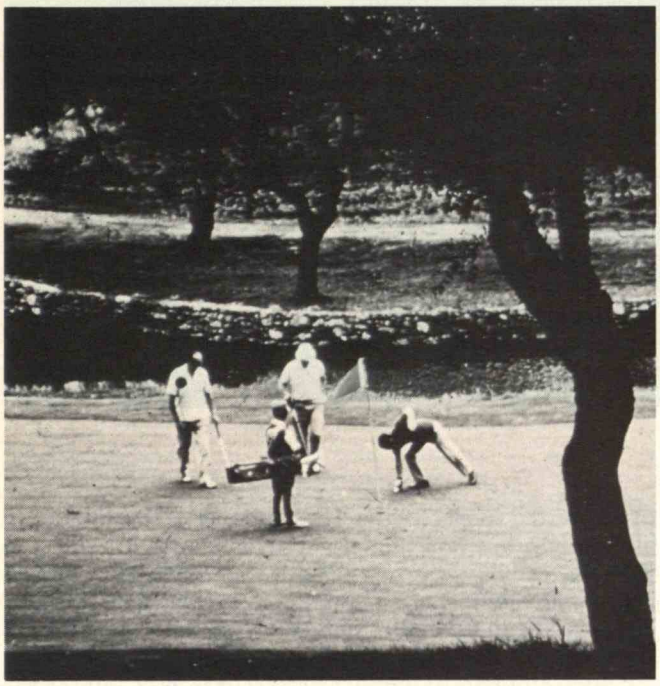
Treated sewage sludge being disposed of at a landfill. New laws requiring advanced sewage treatment will result in large increases in the amount of sludge to be disposed of, adding to the pressure for properly managed landfills.

Deadly Wastes

Unlike relatively benign municipal solid waste, hazardous waste, such as radioactive wastes, pesticides, chemical byproducts, and mercury compounds, pose a substantial present or potential hazard to human or animal health or the environment. These wastes are highly flammable, extremely reactive, toxic, irritating, corrosive, infectious, or are such that they tend to concentrate in organisms exposed to them. The E.P.A. has designated certain substances as toxic pollutants and is constantly evaluating others.

Present disposal practices of hazardous wastes include land dumping or burial, ocean dumping, incineration, and deep well injection. Unfortunately, many of these disposal techniques are not carried out in a prescribed manner and thus can be a threat to public health and the environment. These current practices usually can be made acceptable by following the proper prescribed measures.





The art of burying wastes includes several techniques for safely depositing garbage under a layer of soil. Shown here is the "trench method," whereby the garbage trucks deposit their loads at one end of a trench. At the end of the day, the trench is extended, with the soil used to cover the wastes. Other methods include the "area" method and the "progressive slope" method. In the area method, wastes are spread over the ground and cover hauled in. In the progressive slope method, wastes are piled on a slope, and material in front of the slope is dredged up and deposited over the waste. If these methods are used properly, completed landfills can be perfectly amenable to recreational or other uses, such as the California golf course, shown at the left, which was built on a former landfill.

For instance, hazardous liquid wastes should be detoxified and neutralized before land disposal.

Acceptable disposal of hazardous wastes would include disposal in a chemical waste landfill, chemical fixation, incineration with proper residue disposal and emission control, deep-well disposal in areas where containment can be controlled without harm to the natural environment, and microwave decomposition of waste which can result in recovery of valuable byproducts. On page 47 are shown the various types of hazardous wastes and their treatment methods, and on page 44 the projected amounts of hazardous wastes from the major industry groups.

The E.P.A. Hazardous Waste Management Division has been documenting damage incidents from improper land disposal for several years. Some of the more common kinds of abuses are illustrated by the following cases:

— A New York electroplating firm has been discharging its waste waters into unlined settling ponds since the early 1940s. Although effluents have received chemical treatment since 1958, the surrounding ground water was recently found to be contaminated with toxic cadmium and hexavalent chromium.

— In 1969, Di-Systeon, an insecticide, was added to the soil in a potato field in Idaho. The "empty" paper bags from the pesticide were left in the field, and the wind blew them into the adjacent pasture where 14 head of cattle died, some with convulsions, after licking the bags.

— In 1974, a bulldozer operator was killed in an explosion at an industrial landfill in New Jersey, as he was burying and compacting several 55-gallon drums of unidentified chemical wastes. The victim died of burns.

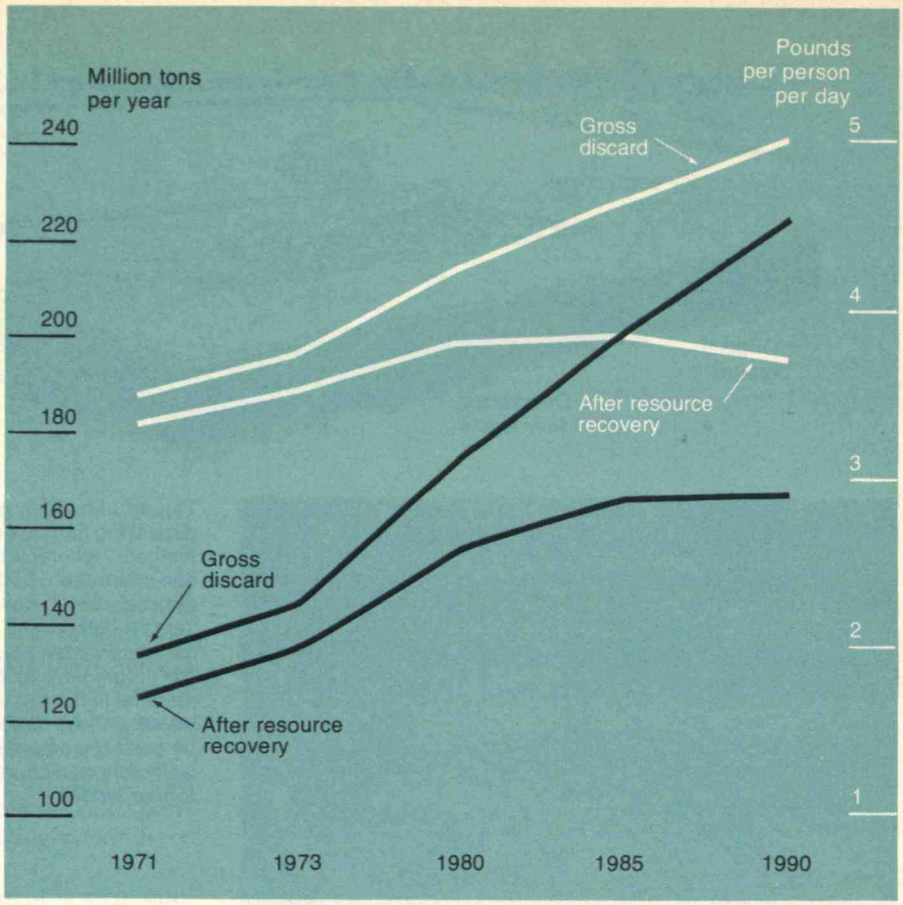
Recently enacted solid waste legislation will allow the E.P.A. to establish control over the treatment, storage, transportation, and disposal of hazardous wastes. This new law also provides for the development of a program of hazardous waste disposal permits and state hazardous waste programs.

"Unnatural" Gas

Gas is produced in landfill sites as a result of the microbial decomposition of the deposited organic matter. This gas consists of methane, carbon dioxide, nitrogen, oxygen, hydrogen sulfide, ammonia, and hydrogen; with methane, carbon dioxide, and nitrogen representing the major volume.

The methane in this gas is at the same time the most dangerous substance, because of its explosiveness, and the most interesting, because it could represent an excellent energy resource. Methane in landfill gas makes up from 0 to 80 per cent of the gas by volume. The amount of methane generated depends on moisture content of the waste, temperature, and amount of organic matter. For each pound of municipal solid waste, up to seven cubic feet of gas is generated, of which about four cubic feet is methane. Methane is explosive in the range of 5 to 15 per cent by volume. Because of methane's low specific gravity, it tends to rise and diffuse through buried waste

Estimates of future solid waste production show that solid waste is a growth industry. Despite recycling, solid wastes will increase because of population increases. (Data from E.P.A. Office of Solid Waste Management Programs)



and soils, and depending on conditions at each site, it may flow laterally.

Gas from landfills has been the cause of numerous accidents. For instance, in September, 1969, in Winston-Salem, N.C., a flash fire fueled by gas from a nearby solid waste landfill killed three and seriously injured seven in a National Guard armory. And in 1975, in Richmond, Va., one person was injured in an explosion which occurred in an apartment next to a landfill. An electric lamp in the apartment was turned on and ignited gas from the landfill. In both these cases, permeable soils allowed migration of the gas, or construction on the completed disposal site did not allow for proper gas ventilation.

In addition to the above damage, landfill gas may also cause vegetative damage. Mr. Franklin Flower of Rutgers University has documented several cases of vegetation destruction in New Jersey that have been attributed to landfill gas. Generally the vegetation dies because of lack of oxygen that has been displaced by the gas.

Despite the large amount of gas produced in a landfill, there are design and construction techniques to control the gas flow safely. Gas may be vented, contained with an impermeable liner, and/or removed by counter-pumping. Gas vents filled with gravel can be installed around the periphery of the site or incorporated in the cell construction. An impervious liner can be used to prevent lateral migration and force the gas to exit through the top of the fill. Counter-pumping can be incorporated at any site and uses negative pressure to draw gas toward the wells.

Landfill gas can also be a significant source of energy. The methane in the gas can be recovered and sold as gas or converted to electricity. Three projects exploring these alternatives are now underway in Los Angeles and San Francisco. These projects will demonstrate current technology for recovering methane and the economics of using this resource. The value of the gas from the projects is 500 B.t.u. per cubic foot (standard temperature and pressure), which can be upgraded to 750 B.t.u. per cubic foot using a molecular sieve concentration process, and further upgraded to pipeline quality (1,000 B.t.u. per cubic foot) by adding propane. Two of the landfill-gas projects aim at upgrading the gas to feed it directly into gas transmission lines, while the third aims at using the gas as a supplemental fuel for a boiler.

Unfortunately, not all landfill sites can be used for methane recovery. Some are too small in volume and could not generate enough methane to be cost-effective. Others are located in areas of high permeability, thus limiting the amount of gas that could be collected. And others may produce gas of poor energy content.

Besides recovering gas from completed landfill sites, the area may also be used as a building site. However, those who would build on completed landfill sites must contend with other problems besides gas from the landfill. Significant settlement will occur at land disposal sites because of decomposition, the landfill's own weight, and superimposed loads by the construction on the site. The most significant cause of settlement is waste decomposition, which is also the cause of gas production. The rate of biological and chemical decomposition is most directly affected by the amount of water in the site. For instance, in Seattle, where rainfall exceeds 30 inches per year, a 20-foot fill settled four feet in the first year after it

Market category	E.P.A. industry group	Types of hazardous wastes	Current treatment or disposal methods
Metals and metal finishing	Batteries Electroplating Primary metals smelting and refining Special machinery	Acid solutions; metals containing sludges	Neutralization; chemical treatment; sanitary landfill; secure landfill; deep-well injection; ocean disposal
Paints, solvents, and coatings	Paint and allied products	Organics; solvents	Incineration; chemical treatment; sanitary landfill; secure landfill
Organics	Organic chemicals Pharmaceuticals Rubber and plastics Textiles dyeing and finishing	Pesticides; biologicals; rubber; plastics	Incineration; biological treatment; chemical treatment; sanitary landfill; secure landfill
Petroleum	Petroleum refining	Oily wastes	Incineration; deep-well injection
Inorganics	Inorganic chemicals Leather tanning	Aqueous solutions of salts, metals, etc.	Chemical treatment; ocean dumping; secure landfill

Hazardous wastes from a wide variety of industries enter the waste stream to be disposed of safely. (E.P.A. data)

was completed. In Los Angeles, where less than 15 inches of rain falls per year, a 75-foot-high landfill had settled only 2.3 feet after three years, and another 46-foot-high section had settled 1.3 feet. Thus, landfills should be evaluated for construction on an individual basis.

In many areas of the country, primarily California, parks and golf courses have been successfully built on completed fills. Generally the recreational areas are located on the completed landfill and the related buildings are located nearby on undisturbed ground. Such location of buildings on undisturbed ground will prevent settlement problems, but the buildings must still be protected from gas migration.

To conclude, while projections show that the amount of net waste to be disposed of will level off by 1985 due to the resources recovered and waste reduction policies, there will still be a need for landfills. There will still be 30 million tons of waste per year more than at present to dispose of. This increasing need puts the burden on environmentally sound disposal techniques, including proper design and operation of both municipal and hazardous waste disposal sites. The recently passed "Resources Conservation and Recovery Act of 1976" calls for the closing or upgrading of existing open dumps and requires that all disposal be made in a sanitary landfill. Tighter regulations such as these will certainly benefit the environment but will place a greater burden on the overall economics of waste disposal.

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A new definition and analysis of energy efficiency helps to clarify policy alternatives.

The Potential for Fuel Conservation

There is great uncertainty about the capacity of the U.S. to meet its needs for energy at acceptable social costs in the remaining years of this century. Recent studies suggest that we cannot achieve "energy independence" by 1985 if energy demand continues to increase at historical rates, even if aggressive policies are successful in stimulating new domestic supplies of oil or gas. There is also much concern about the long-term availability of oil and gas. The view of M. King Hubbert, that domestic oil and gas production can be expected to decline indefinitely, is gaining support, although knowledge of the resource base is so poor that determined exploratory efforts may change the outlook. Coal and nuclear fission resources present other problems. Rapidly increasing capital costs for electric generating plants, quality control problems with nuclear power and continuing uneasiness about its risks, and the controversy over the control of sulfur oxide emissions from coal-fired power plants, are some of the more pressing problems facing the electric power industry today. With these problems operating in concert, the potential for the expansion of coal and nuclear power, at least for the next decade, is highly uncertain. New resources such as synthetics from coal and oil from shale can contribute little to overall supply by 1985, and there may be factors (such as water availability) which absolutely limit their development.

This gloomy scenario has led to increasing attention to fuel conservation, more popularly known as "energy conservation," where supply and demand are brought into balance by emphasizing demand reduction rather than supply increases.

To most people, fuel conservation means such near-term austerity policies as 55-m.p.h. speed limits and lowered thermostats in winter. But several recent studies argue for fuel conservation as a long-term goal — a strategy for simultaneously holding down energy costs, stretching out limited fuel resources, minimizing dependence on foreign energy sources, slowing the introduction of nuclear power to allow time for dealing with unresolved nuclear risks, and protecting the environment. These studies contend that we could reduce our annual growth in energy use from the historical average rate of 3.2 per cent to under 2 per cent. An econometric model by the Ford Foundation's Energy Policy Project suggests that an annual growth rate of 1.8 per cent to the year 2000 could be achieved with little adverse economic effect, and a Conference Board report concludes that historical rates of economic growth could persist over the next decade with energy consumption increasing at perhaps only 1.5 per cent per year.

Such economic studies reflect the growing realization that there is considerable energy "fat" in the U.S. economy today. But these studies do not provide an analytical framework for making quantitative estimates of the potential for fuel conservation.

To assess that potential in quantitative terms, we must answer two questions: What are the real technical possibilities, in both the near and the long term? And what policies are needed to overcome institutional obstacles to the more promising options?

Both of these questions are important. Understanding the technological potential for fuel conservation is essential to establishing realistic goals and priorities. And without effective strategies for overcoming institutional obstacles, conservation goals may never be realized.

In this article we address primarily the first question, putting forth a framework for estimating the technical potential for fuel conservation. We show that this potential is substantial for both the near and the long term.

The use of energy associated with any product is obtained by multiplying two factors: the demand for the product, and the energy required to provide each unit of the product. In this article we focus our attention on opportunities for reducing the fuel inputs required to meet existing patterns of consumer demands. Thus we do not consider here fuel conservation associated with lifestyle changes.

President Carter has focused national attention on the problem of energy conservation, and the authors offer an optimistic plan. They identify conservation strategies based on existing technology which would save some 40 per cent of today's energy use, thus "setting the clock back 17 years on energy consumption." They also propose an agenda for future research and development promising "substantial further long-term opportunities." (Photo: Siteman from Stock, Boston, Inc.)

We Consume "Available Work," Not Energy

To make quantitative estimates of the potential for saving fuel, a measure of energy performance is needed. Thermodynamics provides a useful framework in which to introduce such a measure.

Energy is never created or destroyed; only its form is changed as processes go on. For example, when fuel is burned chemical energy is converted to thermal energy; the total energy in the system is unchanged. The second law of thermodynamics — which implies that the "dis-

	Potential savings (10^{15} B.t.u.)	Total energy demand in 1973 (10^{15} B.t.u.)	Hypothetical energy demand with savings (10^{15} B.t.u.)
Residential sector:			
Replace resistive (electric) heating with heat pump having COP = 2.5	0.60		
Increase air conditioning COP to 3.6	0.40		
Increase refrigerator efficiency by 30 per cent	0.27		
Reduce water heating fuel requirements by 50 per cent	1.07		
Reduce heat losses by 50 per cent with better insulation, improved windows, and reduced infiltration	3.30		
Reduce air conditioning load by reducing infiltration	0.42		
Introduce total energy systems into half of U.S. multi-family units (15 per cent of all housing units	0.31		
Use microwave ovens for half of cooking	0.25		
Totals	6.62	14.07	7.45
Commercial sector:			
Increase air conditioning COP by 30 per cent	0.37		
Increase refrigeration efficiency by 30 per cent	0.20		
Cut water heating fuel requirements by 50 per cent	0.31		
Reduce building lighting energy by 50 per cent			
Direct savings 0.82			
Increased heating requirements −0.21			
Reduced air conditioning required 0.34	0.95		
Reduce heating requirements by 50 per cent	2.25		
Reduce air conditioning demand through improved insulation (10 per cent)	0.08		
Reduce air conditioning demand 15 per cent by reducing ventilation rate 50 per cent and by using heat recovery	0.10		
Introduce total energy systems into one-third of all units	0.64		
Use microwave ovens for half of cooking	0.06		
Totals	4.96	12.06	7.10
Industrial sector:			
Improve housekeeping measures (better management practices with no changes in capital equipment)	3.85		
Use fossil-fuel instead of electric heat in direct heat applications	0.17		
Adopt steam/electric cogeneration for half of process steam	2.59		
Use heat recuperators or regenerators in half of direct heat applications	0.74		
Generate electricity from bottoming cycles in half of direct heat applications	0.49		
Recycle aluminum in urban refuse	0.10		
Recycle iron and steel in urban refuse	0.11		
Use organic wastes in urban refuse for fuel	0.70		
Savings from reduced throughput at petroleum refineries	0.87		
Reduced field and transport losses associated with reduced use of natural gas	0.80		
Totals	10.43	29.65	19.22
Transportation sector:			
Improve automobile fuel economy 150 per cent	5.89		
Emphasize fuel savings in other transportation areas (35 per cent savings)	3.20		
Totals	9.09	18.96	9.87
Grand totals	31.10	74.74	43.64

It is commonly asserted that the automobile offers the greatest opportunities for fuel conservation. While the time scale for substantial improvements is relatively short for the automobile, the authors' analysis, which is summarized in this table, points out that there are comparable fuel-saving opportunities in many cases where low-quality, low-temperature heat is required; these areas make up about 40 per cent of U.S. energy use. In typical residential/commercial low-temperature applications (space conditioning, water heating, refrigeration, etc.) efficiencies now in the range of 2 to 10 per cent can be substantially increased. In industrial applications (e.g., process steam) efficiencies are somewhat higher, but opportunities for fuel savings are still substantial. The summary shows that U.S. energy use in 1973 — 75×10^{15} B.t.u.s. — could have been only 44×10^{15} B.t.u.s had all the authors' conservation proposals been in place. Note that the potential savings associated with a particular conservation measure in this table sometimes depends on the previously listed measures. For example, the savings associated with a reduced air conditioning load is affected by the previous assumption that all air conditioners are more efficient.

orderliness" of a system always increases — tells us that these changes can occur in only one direction, such that energy loses its "quality" or capacity for performing tasks.

The best overall measure of the capacity for doing any task is *work* — the transfer of the highest quality energy from one system to another. Physicist Willard Gibbs gave us the concept of *available work*, a measurable quantity that takes into account the quality as well as quantity of energy transformed in any process.

Consider two systems in the environment of the earth. Suppose that a quantity of energy E in one system is transformed so as to do work on the other system. The available work is defined as the theoretical *maximum* amount of work that could be done in this conversion.

If the energy E is of the highest quality then the available work is

$$A = E. \qquad (1)$$

The gravitational energy stored in water behind a dam and electrical energy are examples of energy of the highest quality. Chemical energy (as given by the heat of combustion) is also high-quality energy, for which the available work is approximately E (typically about 0.9E). In general, for the highest quality energies we may interchange the terms "energy" and "available work" without substantial error.

However, if the energy E is thermal energy at fixed temperature T, then the available work A is less than E, or specifically

$$A = E\left(1 - \frac{T_0}{T}\right), \qquad (2)$$

where T_0 is the temperature of the ambient environment, and with both T and T_0 given on the absolute temperature scale (that is, in Celsius units with the zero set at -273°C).

The efficiency of an energy conversion system is usually defined as the amount of desired energy or work provided by the system, divided by the energy input to the system. Because it is based on the first law of thermodynamics, which holds that energy is neither created nor destroyed, this concept of efficiency is often called the "first-law efficiency." This efficiency concept enables one to keep track of energy flows and is thus useful in comparing devices of a particular type. However, it is wholly inadequate as an indicator of the potential for fuel savings. Several examples illustrate this point.

Household furnaces are typically said to have an efficiency of about 0.6, meaning that 60 per cent of the heat of combustion of the fuel is delivered as useful heat to the house. This measure suggests that a 100-per-cent-efficient device would be the best possible. But this is incorrect because a heat pump could do better.

A heat pump is simply an air conditioner operating in reverse. It extracts heat energy from the out-of-doors and transfers it at a higher temperature to the interior space, thereby making available as heat more than 100 per cent of the electrical energy it consumes.

Air conditioners are rated by a coefficient of performance (COP), which is the ratio of the heat extracted to the electric input. A typical air conditioner has a COP=2 (a 200-per-cent efficiency), a measure which provides no hint of the maximum possible performance — a COP much greater than 2.

In the most modern fossil-fuel-fired power plants about 40 per cent of the fuel energy can be converted to electrical energy. In this case the maximum theoretical efficiency is less than 100 per cent, because of the limitations set by the second law of thermodynamics.

In all these examples the efficiency used is only a partial measure of performance. That is because losses of energy quality, in addition to losses of energy, are inherent to any process. Examples of quality losses are heat flow from higher to lower temperature and the mixing of materials. A more useful measure of efficiency, therefore, would take into account both quantity and quality losses and would show how well a particular energy conversion system performs relative to an ideal one in which there is loss of neither quantity nor quality. The available work concept provides a basis for formulating such an efficiency measure.

The first step in formulating a new efficiency measure is to define the task, such as heating a building, propelling an automobile, or producing steel. The available work consumed in carrying out this task is a direct measure of the expenditure of fuel. In an ideal process this available work would correspond to the absolute minimum expenditure of fuel for the task. But a real process involves losses, so that the actual work consumed, A_{act}, is larger than A_{min}. A suitable measure of efficiency, therefore, is

$$\epsilon \equiv \frac{A_{min}}{A_{act}}. \qquad (3)$$

This equation for efficiency shows that fuel consumption A_{act} can be reduced either by increasing the efficiency or by modifying the task to be performed (that is, by reducing A_{min}). Because this measure of efficiency shows performance relative to what is possible within the constraints of the second law of thermodynamics, it has been called the "second-law efficiency." In what follows we shall use the term "efficiency" in this sense. This efficiency concept was introduced and applied to a wide range of fuel-consuming activities in a recent American Physical Society study.

The distinction between ϵ and the conventional first-law efficiency can be illustrated with the Carnot engine, an idealized device which makes the fullest use possible of heat E extracted from a reservoir at temperature T. For this engine $A_{act} = A_{min}$ and $\epsilon = 1.0$. In contrast, the first-law efficiency is $A_{min}/E < 1$, suggesting erroneously that this ideal heat engine could be improved upon.

The calculation of A_{min} varies with the task. For a task that involves work W (for example, turning a shaft),

$$A_{min} = W \qquad (4)$$

For the transfer of thermal energy E to a reservoir at temperature $T > T_0$ (for example, heating a room),

$$A_{min} = E\left(1 - \frac{T_0}{T}\right). \qquad (5)$$

It is noteworthy that in this particular example the minimum available work is actually less than the amount of heat delivered, because the ideal process for delivering heat involves use of a heat pump which extracts thermal energy from the ambient environment.

Second-law efficiencies for fuel-consuming activities throughout the economy can de calculated using equation (3). The results for some important examples are summarized in the table on page 54, which shows that for most activities second-law efficiencies are less than 10 per cent, clear evidence that energy is being used very in-

While it is true that enormous improvements in fuel utilization could be made using existing technology, fuel conservation in the longer term could be greatly enhanced by better understanding of a large number of technological questions. Most of the topics on this agenda for new research and development were suggested in a study of energy conservation mounted in 1975 by the American Institute of Physics.

	Buildings	Transportation	Industry
Basic research	Physiological requirements for energy services (lighting, space conditioning) as a basis for revising standards Aerodynamic studies of buildings Heat transfer, at a "micro" level, across various boundaries	Studies of the combustion process and development of advanced diagnostics Improving combustion efficiency through use of emulsions of fuel with water or methanol	Heat transfer at interfaces Two-phase flow Transport in membranes Solid electrolytes Charge transfer at electrolyte/electrode interfaces
Improved devices and materials	Thermal diodes (insulation with different heat conductivities in different directions) Building materials with high specific heats for thermal stability Fuel cells for decentralized power generation New types of windows to control heat loss and insulation	Advanced engine cycles (Diesel, Rankine, or Stirling) Battery-electric or hybrid Diesel-electric autos Continuously variable transmission Flywheel storage of braking energy Absorption air conditioning	Solar-diesel steam generator Modulated capacity compressors for heat pumps and refrigeration Materials development for high temperatures
Analysis and instrumentation of existing processes	Diagnostic instrumentation for research and inspection (e.g., local heat-flux meter, air exchange meter, local air velocity meter) Instrumentation for user feedback (e.g., to signal the consumer when he is consuming electricity at the system peak)	Instrumentation for user feedback such as a fuel-flow meter or a specific fuel consumption meter (in gallons of gasoline per ton-mile, say) Analysis of energy loss modes (air drag, rolling resistance, braking energy) in different types of trucking	Determination of second-law efficiencies for industrial processes Development of indices measuring energy requirements for various kinds of economic activity
Systems analysis	Designs to take advantage of local natural conditions Reassessment of practice for designing baseload energy system for extreme conditions Time and zone control of lighting and temperature	Strategies for electrification of transportation that would improve electric load factor Crashworthiness of lighter cars Tradeoffs in function among tires, wheels, and suspension, aimed at decreasing rolling resistance	Assessment of decentralized versus centralized power generation Materials recycling and reuse of fabricated items in specific industries Combined electric and heating systems: optimization and development of strategies for integration with utilities

efficiently today. For example, the typical household oil-fired furnace has a second-law efficiency of only 5 per cent, compared with its first-law efficiency of 60 per cent. The latter figure, often quoted for household furnaces, gives the misleading impression that only a modest efficiency improvement may be possible, while the second-law efficiency correctly indicates a 20-fold maximum potential gain.

How close can we expect efficiencies to approach the ideal limit of $\epsilon = 1$? Examination of experience with high-efficiency systems helps provide insight for making judgments about practical long-term goals. The table (*page 54*) shows that, contrary to the popular misconception that it is inefficient, electric power generation is one of the more efficient conversion processes in the economy today. (It is only when the power generation system is extended to include especially wasteful uses of electricity that the overall efficiency is often very low; for example, $\epsilon = 0.025$ for electric resistive space heating.) Furthermore, new fossil-fuel-fired plants achieve ϵ of up to 0.40, and combined-cycle systems now being developed (the heat from combustion is used first to drive a gas-turbine-powered generator and the gas turbine exhaust is then used to make steam for a conventional steam turbine) are expected to achieve efficiencies approaching 0.55. All these energy conversion processes start with fuel combustion, for which $\epsilon = 0.70$; so, in a sense, combined cycles may achieve 0.55 out of a possible 0.70 in efficiency.

These high efficiencies are associated with highly engineered, costly, and rather inflexible devices, and they may not represent a practical goal for most systems. Nevertheless, study of a variety of high-efficiency devices and processes, some described below, suggests that goals for ϵ in the range from 0.2 to 0.5 are reasonable for ultimate practical systems. Values at the high end of this range are more likely to be characteristic of highly engineered devices designed for specialized tasks; values at the low end are more likely for flexible, less sophisticated devices suitable for wide applications.

Here are some examples of how these concepts of energy and efficiency demonstrate opportunities for substantial fuel savings arising from both efficiency improvements and task modification.

Better Mileage for Moderate Sized Cars

Consider first the automobile. The task to be performed is the propulsion of a vehicle of given external characteristics (weight, tires, wind resistance, brakes, etc.) under average driving conditions. The efficiency would be the ratio of the theoretical minimum fuel required to perform this task (A_{min}) to the actual amount required by the vehicle in question (A_{act}).

The theoretical A_{min} for today's average 3,600-pound automobile is about 1,000 B.t.u.s per mile. This average automobile actually consumes 9,200 B.t.u.s per mile (14 m.p.g.), resulting in an efficiency $\epsilon = 0.11$. The American Physical Society study of energy conservation (*see the references*) identified a series of improvements that could be accomplished with today's technology: a better load-to-engine match could yield an efficiency gain from 0.11 to 0.12; and the use of radial tires, modestly improved streamlining, and a 20-per-cent weight reduction would reduce A_{min} to 740 B.t.u.s per mile. The combined effect would be to reduce fuel consumption to 6,200 B.t.u.s per mile (20 m.p.g.) Further improvements possible over the next few years could boost the efficiency to about 0.17 with a more efficient transmission and an improved engine design (Diesel, Rankine, or Stirling), while further improvements in streamlining, development of a better tire/suspension system, and a further 5-per-cent weight reduction could bring A_{min} down to 630 B.t.u.s per mile. Such improvements could mean that automobiles of the 1990s would differ little in performance from today's cars but would typically travel 30 to 35 miles on a gallon of fuel. The average weight of these cars would be only 25 per cent less than today's average. (Of course, cars smaller than this with comparable fuel economy are being built with present technology.)

Warming to the Conservation Task

Potential savings in space heating are immense, because there are opportunities for considerably reducing heat losses (i.e., reducing A_{min}) and because present heating system efficiencies are low.

For average U.S. winter weather, the efficiency ϵ of a typical gas furnace system is 0.05, a figure obtained as follows. The task is taken to be the delivery of heat at 86° F. into the useful space of a given building (with the level of insulation specified). According to equation (5), the minimum available work associated with the delivery of heat E, when the outdoor temperature is 40° F., is $A_{min} = 0.084E$. Also, we know that, for a furnace that delivers 60 per cent of the energy content of the fuel to the desired space, $E = 0.6A_{act}$. Using equation (3) we thus obtain $\epsilon = 0.05$. With a lower outdoor temperature, the efficiency would be higher.

First consider how to reduce the minimum available

We usually think of efficiency as the ratio of energy or work provided by a particular device to that which was consumed by it. But this conventional measure is wholly inadequate as an indicator of the potential for fuel savings; hence the authors' emphasis on "second-law efficiency," the performance relative to that which is possible for a given task.

Energy-consuming activities (current technology)	Second-law efficiency (per cent)
Residential and commercial:	
Space heating:	
Fossil-fuel-fired furnace	5
Electric resistive	2.5
Air conditioning	4.5
Water heating:	
Gas	3
Electric	1.5
Refrigeration	4
Transportation:	
Automobile	9
Industrial:	
Electric power generation	33
Process-steam production	33
Steel production	23
Aluminum production	13

work (A_{min}) required to heat a typical house. About 60 per cent of the heat losses are from conduction through walls, roof, windows, and floors. The American Physical Society study estimates that with improved insulation and well designed windows these losses could reasonably be cut to below one-third of present values. The remaining 40 per cent of the heat losses are due to heating and humidification of fresh air; studies have shown that typical rates of air exchange in buildings are unnecessarily high, and it is not unreasonable to reduce the ventilation rate some 80 per cent.

These strategies, which could cut total heat losses nearly four-fold, would involve modest innovations in design and development. Such a four-fold reduction would mean that in many buildings no fuel would be needed on average winter days, when a temperature differential of 30° F. is required between outside and inside, to supplement the heat provided by sunlight through windows, by the lights and appliances, and by the body heat of residents.

On colder days a small heat pump or pumps could be used. If outside air is the heat source for an electrically driven heat pump, the heat pump typically delivers two or three times as much heating as is represented in the electricity consumed (that is, COP = 2 to 3). If well or lake water (at, say, 55° F.) is used as a heat source, a COP of 4 is achievable today, corresponding to $\epsilon = 0.10$.

The net effect of thermal tightening of the building shell and of using such an efficient heat pump would be to reduce the primary fuel consumption for space heating to one-eighth of that required for a gas furnace heating a house with insulation characteristic of an average house today.

High-Rise Cooling

Consider a typical new office building in New York City with ten stories and one million square feet of office space. Though the efficiency of air conditioning in a typical new office building in New York City is low (likely to be no more than 0.04 on a hot (90°F.) summer day), the easiest way to achieve fuel savings is by reducing the air conditioning load — i.e., by reducing A_{min}. In this building, only one-sixth of the air conditioning load is due to heat conduction from the outside and solar radiation through windows. Over half of the load is due to heat generated by lighting (about six watts per square foot) and about one-fifth is due to ventilation (20 cubic feet per minute per person).

It is reasonable to reduce illumination levels to 1.5 watts and ventilation to five cubic feet per minute; these efforts to reduce A_{min} would cut the total air conditioning load by more than 50 per cent. (But at least ten cubic feet per minute of ventilation per person would be required for a building in which smoking is permitted everywhere. In the case of this office building the extra air conditioning load associated with smoking requires burning 20 gallons of fuel oil each hour at the power plant.) Among further practical modifications, the most significant would be the use of heat exchangers to recover "cool" from exhausted air. Pursuing all these measures would lead to about a 70-per-cent reduction in the air conditioning load.

An alternative to electric central air conditioning is the heat-driven air conditioner based on desiccation. Such a device, with a COP = 0.73, offers the potential of substantial savings if solar energy is used as a partial heat source. Using sunlight incident on a collector covering the roof of the building as a partial heat source for this device, and adopting the load reduction measures considered here, could lead to a system in which the total primary fuel consumption for air conditioning was about one-eighth of that in today's large office building with electric-powered air conditioning.

Industrial Steam Production

The first-law efficiency for converting fossil-fuel energy to steam in industry is typically an impressive 0.85, but the second-law efficiency is only 0.33 for steam at 400° F. Producing steam by burning fuels represents a waste of available work. This is because the high flame temperatures of fuel combustion (up to about 3,600° F.) represent energy of very high quality, but the temperatures required for industrial process steam are typically 400° F. or lower. Substantial fuel savings can be achieved if the high-quality, high-temperature energy available from combustion is first used to make electricity in a heat engine, with the "waste" heat from this device used for low-temperature process-steam applications. This "cogeneration" of electricity and process steam is an important application of the more general fuel-saving strategy of "cascading," where the energy available in combustion is sequentially degraded through a series of uses.

The second-law efficiency for cogeneration is typically between 40 and 45 per cent, compared to about 33 per cent for the separate production of steam and electricity. The resulting savings are actually much more impressive when expressed another way. If only the excess fuel beyond that required for steam generation is allocated to power production, the fuel required to produce a kilowatt-hour of electricity is reduced to about half of that required in conventional power plants. The national potential is truly great, as process steam is a major energy-consuming activity in the economy, accounting for about 17 per cent of total energy use.

The most promising application of steam-electricity cogeneration appears to be in industrial plants, where electricity could be produced as a by-product whenever steam is needed. Various cogeneration technologies could be employed. In a steam-turbine system, steam used to drive the power-generating turbine would be exhausted from the turbine at the desired pressure and (instead of being condensed with cooling water, as at a conventional power plant) delivered to the appropriate industrial process. With a gas-turbine system, the hot gases exhausted from the power-generating turbine would be used to raise steam in a waste heat boiler. The gas-turbine system is the more efficient of the two, typically with $\epsilon = 0.45$ compared to $\epsilon = 0.40$ for a steam-turbine system; in addition, because it produces several times as much electricity for a given steam load, the gas-turbine cogeneration system could yield considerably greater total fuel savings than the steam-turbine system.

Recent studies on the overall potential for cogeneration have been carried out by Dow Chemical Co. and by Thermo Electron Corp. The latter's study shows that by 1985 electricity amounting to more than 40 per cent of today's U.S. consumption (generated with the equivalent of about 135,000 megawatts electrical of baseload central station generating capacity) could be produced economically with gas turbines as a by-product of process steam generation at industrial sites. While the gas turbines in most common use today must be fueled with gaseous or liquid fuels, it is likely that over the next decade high-pressure fluidized-bed combustors will be available as an economical method of firing gas turbines directly with coal.

To produce power most economically, an industrial installation that generates electricity as a by-product of process steam production would often produce more electricity than could be consumed on-site. Thus the cogeneration unit should be interconnected with a utility and could substitute for some central-station baseload generating capacity. But such an arrangement is often difficult under existing utility policies. Considerable modification of utilities' transmission, control, and perhaps storage systems may be necessary if interconnected cogeneration capacity is developed on a large scale.

The production of process steam as a by-product of power generation at large central station power plants is an alternative to cogeneration at industrial sites. However, such steam production does not lead to a significant increase in ϵ, since only about 1.5 per cent of the available work originally present in the fuel is discharged in the cooling water, which has an average temperature of about 100° F. If the waste heat is to be useful for industrial processes, power plant operations would have to be modified to produce heat at more useful temperatures (200° to 400° F.). But this would reduce the electrical output, and this change could lead to a net loss of available work unless essentially all the heat were put to effective use.

Not only are the potential gains of by-product steam generation small, but there are serious implementation difficulties as well. Because it is uneconomic to transport steam long distances, steam-using industries would have to be near the power plants from which their heat is supplied, and this is a condition difficult to fulfill. There is also a serious mismatch in time: large central-station power plants require six to ten years for construction and are designed for a quarter-century or more of service. For these reasons industrial cogeneration is favored.

The Overall Potential of Conservation

Having considered a number of examples, we now turn to an estimate of the overall fuel savings potential in the economy through adopting measures to increase ϵ and to decrease A_{min}. We take into account technologies that are either commercial now or are likely to be commercial in the near future, so the estimates we make now are less ambitious than some of the potential savings estimates we have made above. Specifically, we ask what U.S. energy consumption would have been in 1973, had we been a nation of energy thrift.

Our conclusion is that the 1973 living standard of the U.S. could have been provided with about 40 per cent less energy (*see the table on page 50*). Nearly 60 per cent of the potential savings lies in four areas: space conditioning, the automobile, industrial cogeneration of steam and electricity, and commercial lighting. While total consumption of electricity is reduced by only 30 per cent in

the hypothetical energy budget for 1973, central-station power generation is reduced by about 60 per cent because of the large amount of power generated by industrial cogeneration and total energy systems.

One way to interpret these results is to note that they set the clock back 17 years on energy consumption. That is, growing at the historical rate from the level of this hypothetical energy budget to the actual 1973 level would require 17 years.

We believe that with an aggressive fuel conservation program the fuel-saving technologies of the general type we propose in this table could in fact be brought into use in the U.S. within two decades. This strongly suggests the possibility of zero energy growth out to the early 1990s without jeopardizing overall economic growth. Through fuel conservation efforts, the growth in aggregate demand for products would be compensated for by reductions in the average energy required to provide a unit of product.

Actually, such a focus on 1973 fuel-use patterns tends in two ways to underestimate potential future fuel savings. First, uses such as residential air conditioning and electric resistive space and industrial heating are major growth areas where savings opportunities are substantial; second, fuel-conserving lifestyle changes not considered here are already taking place. The growing shift to small cars is an especially important example of such a change.

Our analysis shows that efficiencies of fuel use are in general higher in the industrial sector (with ϵ typically in the range 0.15 to 0.35) than elsewhere. This suggests that long-term fuel savings opportunities, beyond those indicated in our table, may be limited in the industrial sector, though this observation must be tested through careful analysis of the major industrial processes. Of course, substantial industrial fuel savings over the long term could be realized by shifting the mix of economic output from energy-intensive products to those which require less energy per dollar of value added. Such possibilities have not been taken into account here, where we have estimated potential savings only for the existing pattern of demand for goods and services.

In contrast, because efficiencies are at present so low in the residential, commercial, and transportation sectors, technological innovation in these areas could lead to substantial long-term savings beyond those tabulated, if the appropriate research and development is pursued.

What are the economics of fuel conservation measures? Investments in fuel-saving technology are likely to be costly, but as our supplies of low-cost energy resources diminish these costs may well be less than the costs of increasing our energy supply.

If a particular process requires fuel input at an average rate S_0 (in thermal kilowatts per unit of daily output, say) and costs C_0 (in dollars per unit of daily output), and if the corresponding values for the fuel savings option are S and C, then the capital costs of the conservation option can be expressed as

$$\frac{C-C_0}{S_0-S} \qquad (6)$$

in dollars per thermal kilowatt saved. This measure of capital costs can be compared to corresponding costs for energy supply options.

We illustrate this with a few examples. Expressing capital costs as (1974) dollars per thermal kilowatt saved, we find that replacing electric resistive heating plus a central air conditioner with a heat pump (COP = 2.7) costs \$50 to \$120 per kilowatt saved; retrofitting a house with insulation and storm windows costs \$450 per kilowatt saved; and the installation of waste-heat recovery units on a heat-treating industrial furnace, \$100. The extra capital required to save fuel with a cogeneration system is in fact negative, except for very small plants, simply because the cost of a suitably large combined system is less than the cost of separate electricity and process steam generating facilities.

By comparison, a large coal or nuclear power plant, along with the associated transmission and distribution system, today costs \$480 to \$650, respectively, per thermal kilowatt of utilized capacity. Only the home retrofitting example is close in capital costs to these investments required for new capacity; it is, in fact, one of the most capital-intensive conservation options. Insulating *new* homes would certainly require less capital.

These numbers are rough, but they are illustrative of the kinds of calculations that should be performed. A careful comparison is needed of the capital requirements and the life-cycle costs for all major conservation options and the corresponding costs for conventional practices, taking into account the entire system from resource extraction to the point of end use in each case.

Research Opportunities

Research and development opportunities relating to fuel conservation span a wide range, extending from basic physical research through new or improved devices and materials and analysis and instrumentation for existing devices and physical systems. There is also need for better understanding of systems problems and institutional and

policy issues. Selected examples of research opportunities in the first few categories are presented in the table on page 52.

It is clear that much technology for fuel conservation is available today but is not being widely used because of institutional obstacles. Better understanding of these problems and assessments of alternative plans for overcoming them should be given close attention in fuel conservation research programs. Among the more general institutional problems, high priority should be given to methods for providing citizens with life-cycle-cost information on energy-related purchases (e.g., heating and cooling systems and those appliances that consume large amounts of energy); new institutional arrangements for financing fuel conservation measures (examples include home insulating services provided by a utility, with financing charges added to the fuel bill, and regulations that require mortgages to cover additional investments needed to minimize life-cycle costs); the relative merits of reliance on energy price, regulations, taxes, and subsidies for achieving fuel conservation goals; the implications for fuel consumption of alternative courses for economic development; and economic (especially employment) implications of fuel-conservation policies.

One especially attractive feature of research on fuel conservation is that it tends to be less costly than research and development on fuel supply. Moreover, with adequate funding, the time required to generate useful results should often be short relative to that for supply-oriented research.

Putting Conservation on the National Agenda

Two years after the "energy crisis" dramatized the problems of U.S. energy supply, little has been done to implement serious fuel conservation programs in the U.S. or even to mount a significant research and development program in this area. This inaction no doubt reflects in part a general lack of understanding of what can be achieved with fuel conservation technology to bring energy supply and demand into balance. It also reflects the existence of institutional constraints which tend to reinforce this limited vision.

The authors are confident that a better understanding of the potential for fuel conservation will lead to a change in this situation. We have shown that the potential based on existing technology is large, and we suggest that substantial further long-term opportunities could arise if the appropriate research and development is pursued. One of the nation's highest priorities should be to make these opportunities evident to political and industrial decisionmakers and to citizens generally.

It appears to us that the physical limitations to fuel conservation are considerably less pressing than many of the public risks and capital cost problems posed by substantial increases in energy supply. Furthermore, if our assessment is correct, a shift in emphasis from energy-supply to fuel-conservation technology will involve a net reduction in capital and very likely an increase in productivity of the economy as a whole.

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Much of the information in this article is based on a summer study by the American Physical Society and on research conducted for the Energy Policy Project of the Ford Foundation. Dr. Ross was a Director of the A.P.S. study, and Dr. Williams was Chief Scientist for the Energy Policy Project. Dr. Williams' work was in part supported by the Max and Anna Levinson Foundation.

"While the dangers of plutonium were understood from the beginning of the nuclear age, they were regarded as dangers located far in the future. Now the future is here."

Plutonium, Proliferation, and Policy

The problem of plutonium has come to dominate our thinking about nuclear energy. This element is both a nuclear explosive and the key to a virtually inexhaustible source of energy. While its dangers were understood from the beginning of the nuclear age, they were regarded as dangers located far in the future.

Now the future is here. Plutonium-bearing spent fuel from civilian power reactors is accumulating in storage ponds around the world. More and more nations, some of them in the less-developed category with modest nuclear programs, are planning or have expressed interest in commercial-scale reprocessing plants with the avowed purpose of separating plutonium for recycle in existing nuclear power stations or storing it against future use in breeder reactors.

In recent years, we have been concerned about the easy access to plutonium that ownership of reprocessing facilities would permit, and we have come to deplore plans by individual nations to acquire such facilities. We have done so despite the fact that a desire for plutonium has been kindled by almost universally held official assumptions — our own included — that the use of plutonium is a natural, legitimate, desirable, and even indispensable result of the exploitation of nuclear power for the generation of electricity. The powerful grip of this assumption has complicated efforts to prevent this nuclear explosive material from becoming widely and freely available throughout the world. On October 28, 1976, for the first time in the 30-year history of nuclear energy for peaceful purposes, the United States government brought this basic assumption into question.

In a major statement on nuclear policy, President Gerald R. Ford said, "I have decided that the United States should no longer regard reprocessing of used nuclear fuel to produce plutonium as a necessary and inevitable step in the nuclear fuel cycle and that we should pursue reprocessing and recycling in the future only if they are found to be consistent with our international objectives."

Mr. Ford emphasized that he did not see that the choice had to be made between nuclear power and proliferation, but he did suggest that it may well have to be made between proliferation and plutonium. In that event, "avoidance of proliferation must take precedence over economic interests."

The statement provided a new and less confining context for nuclear policy making. It did not dispose of the problems of the relationship between proliferation, plutonium, and civilian nuclear power programs; the hard decisions have been left to President Carter's administration. But it did open the way to serious consideration of how to go about weakening the tie between the civilian and possible military uses of plutonium.

There is a melancholy lesson in the fact that today, after 30 years, we have come almost full circle in our thinking about controls over the dangerous side of nuclear energy.

A Little History

At the end of World War II, it was clear that an uncontrolled exploitation of atomic energy by national governments represented a threat to world peace. In 1946, the United States went to the United Nations with a plan — prepared by the so-called "Acheson-Lilienthal Committee" and presented by Bernard Baruch. The drafters described it as a "collaborative approach to a problem which could not otherwise be solved." It provided for international ownership and control of the "intrinsically dangerous" aspects of atomic energy; these included the "nuclear fuel cycle" — mining, milling, enrichment, fabrication, reprocessing. The proposal failed in consequence of the Soviet Union's veto.

At that time, the Congress was determined to preserve the secrets of atomic weapons until controls were instituted. The 1946 Atomic Energy Act prohibited not only U.S. nuclear exports, but exchanges of information as well, until Congress found by joint resolution that "effective and enforceable international safeguards against the uses of atomic energy for destructive purposes" were in place. No such finding was ever made.

Safeguards originally meant protection. One element of protection lies in inspection of nuclear materials and facilities; the value of inspection in this context is to discover wrong-doing well in advance of illicit weapon fabrication. The limitations of inspection as a safeguard were acknowledged at the start. The Acheson-Lilienthal group concluded, "A system of inspection superimposed on an otherwise uncontrolled exploitation of atomic energy by national governments will not be an adquate safeguard."

In 1953, President Eisenhower radically changed U.S. nuclear policy with his Atoms for Peace proposal. In his words, "to hasten the day when the fear of the atom will begin to disappear from the minds of people," stocks of nuclear material were to be contributed by the weapon states, along with appropriate technical assistance, to a new International Atomic Energy Agency (I.A.E.A) which would distribute it for peaceful uses. The problem of safeguards did not appear formidable. As Eisenhower put

Victor Gilinsky
Commissioner
U.S. Nuclear Regulatory Commission

it, "The ingenuity of our scientists will provide special safe conditions under which such a bank of fissionable material can be made essentially immune from surprise seizure."

I have always wondered what he had in mind. The problem of sudden seizure is still outstanding.

As things turned out, weapon stockpiles were not melted down. Rather, Atoms for Peace — under a radically altered Atomic Energy Act — grew into an enthusiastic worldwide distribution of the nuclear technological wealth which had been amassed in the United States. The nuclear policy of 1946 was turned upside down in 1954, when the insularity of the original atomic energy legislation was abandoned in favor of aggressive encouragement of nuclear power. Our peaceful nuclear know-how was shared as fast it developed. This policy resulted in U.S. assistance in the establishment of cooperative development in the Common Market countries through EURATOM, as well as the International Atomic Energy Agency. As it turned out, I.A.E.A. did not become a bank and protector of nuclear material, but rather evolved into an inspection service to cover the bilateral commercial arrangments of its members.

So long as only reactors and low-enriched uranium were involved, periodic inspection provided a reasonable measure of protection against appropriation. Moreover, our own bilateral arrangements, or Agreements for Cooperation, were initially quite strict — at least in the sense that they strictly controlled access to highly enriched uranium and plutonium. In addition, our monopoly position provided considerable assurance that our agreements would be kept.

Over the years, however, as our bilaterial research and technical assistance programs fueled the mushrooming growth of commercial nuclear power abroad, we paid more attention to the promotional function of our agreements than we did to their control provisions. This led us to see plutonium more in the light of its use in future technologies than in the present reality of its weapons potential.

In assessing the dangers associated with possible misuse of plutonium and highly enriched uranium, we were influenced in the early days by the assumption that nuclear weapons development required long and costly programs and that even separated plutonium or highly enriched uranium could not easily or rapidly be turned into military explosives. This led to other careless assumptions; for example, that the technique of reactor safeguarding already in place — inspections and audits — would be adequate to provide vital early warning of illicit attempts to divert separated plutonium when it eventually began to accumulate in stockpiles; and also, that warning well in advance of illicit bomb fabrication was perhaps not really essential. These miscalculations, combined with the fact that the problem was not an immediate one, are the key to the difficulties we are now experiencing in curbing further proliferation.

This weighing of the relative importance of development and protection — along with the conviction that the reactor byproduct had an important commercial future and even that the long-term use of nuclear power depended on it — resulted in a gradual loosening of controls over dangerous materials derived from U.S. exports.

The present situation is that no plutonium controls exist in agreements with EURATOM and the I.A.E.A., and where plutonium produced in U.S. reactors from non-U.S. fuel is concerned are entirely lacking in all other agreements. Permission to reprocess U.S. fuel is conditioned in some cases on the "safeguardability" of the separation facilities. Strictly interpreted, this requirement can still provide effective U.S. control, but only if we acknowledge that such a condition cannot be met; in other words, the only control available at present lies in a veto of national reprocessing and stockpiling. Unfortunately, the State Department clouded that requirement in early 1976 by agreeing, at the I.A.E.A., in effect, that the German and French exported plants are in fact "safeguardable" by I.A.E.A inspection techniques. In following this course we have finally arrived at a situation in which a country can come arbitrarily close to going nuclear with our materials without violating any agreements.

These are the consequences of taking for granted the future utilization of plutonium, regarding reprocessing as a perfectly legitimate commercial activity, and assuming the efficacy of "safeguarding." (While it is a cliché of the inspection trade that diversion cannot be *prevented* by inspection safeguards, there is nevertheless a general human tendency to relax and assume protection once they are in place. Calling the inspections "safeguards" contributes to the illusion.)

It was too long before we perceived the dangerous implications of our various overseas customers' moves toward domestic reprocessing of spent reactor fuel and national stockpiling of plutonium extracted from it. And we might not have seen it yet had not the Indian explosion of a nuclear device, made possible in just this way in 1974, made it alarmingly clear. This event provides a textbook case: the lesson lies in the fact that in taking the

"President Eisenhower said, 'The ingenuity of our scientists will provide special safe conditions under which a bank of fissionable material can be made essentially immune from surprise seizure.' I have always wondered what he had in mind."

plutonium route (with our acquiescence) India acquired a nuclear explosives option along the way — and exercised it.

The technical rationale for the Indian reprocessing program lay in India's long-range pursuit of a machine that ran on plutonium and produced more fuel than it consumed — the breeder reactor. That country, with its limited fuel resources, always saw the breeder as the key to energy independence. And in this India was not alone; the more advanced nations read the signs the same way, but in addition saw the breeder as an instrument to break the U.S. nuclear fuel monopoly, an important element in commercial competition in this new technology.

Enthusiasm for the breeder, initially fanned by the American assistance programs, overshadowed the dangers of weapons proliferation implicit in the use of plutonium as fuel. And control provisions written into agreements we are still trying to live with today reflect this.

"Nobody Had Been Minding the Store"

The Indian explosion in 1974 produced what might be described as slow double-take throughout the world, and particularly in the United States. (The key word is "slow.") What started as a general but vague sense of unease about where our nuclear export policies were leading us has built, over the past year, into a near-desperate flurry of activity to bring the threat of further proliferation under control. The Congress, disturbed by reports of the German sale of reprocessing and enrichment facilities to Brazil and the French sale of reprocessing facilities to South Korea and Pakistan, began to take a close, hard look at what had been happening and what could be done about it.

The State Department held secret meetings with other nuclear suppliers. The export guidelines developed there, however, did not put much of a crimp in the commerce in plutonium separation facilities. In December 1976, France and Germany agreed to new guidelines in effect embargoing further sales of reprocessing plants. It appears this action, however, is to affect future sales and the status of the Brazil and Pakistan deals is unclear. The French and Germans put down objections by maintaining quite truthfully that, in the Brazilian and Pakistani sales, they were complying with the safeguards guidelines worked out among the suppliers. Of course, since separated plutonium can be turned to weapons use in a matter of days, it is difficult to see how inspection safeguards over reprocessing and separated plutonium can give any protection. In subscribing to the fiction that they could, the U.S. gave up its best argument against the sales. The fact that it did so is probably accounted for by a combination of factors — the resistance of competitors, a reluctance to chance "undermining" the integrity of the I.A.E.A. system by suggesting it was inadequate to safeguarding national reprocessing and stockpiling, and a simple failure to comprehend in time that no technical "fix" was in sight. In the end, the best that could be managed by the Department of State was to back the South Koreans off their purchase of a reprocessing plant.

In June there was a sharp split over export licensing within my own agency, the Nuclear Regulatory Commission, which has regulatory responsibility over nuclear exports. For the first time in the 25-year history of nuclear exports, written opinions were produced — in this case justifying and dissenting from granting of a license for the export of a reactor to Spain. Disagreement within the Commission surfaced again publicly some weeks later, this time over licensing of a nuclear fuel shipment to India.

The general agitation was certainly not diminished when it was revealed, after much pulling and hauling between Congress and the nuclear bureaucracy, that U.S. heavy water sold to India strictly for peaceful uses had played a role in the Indian nuclear explosion, a fact which did not even produce a protest from the U.S. government. Even more embarrassing was the revelation that the Executive Branch had failed to ask India about this at the time (perhaps fearing what the answer would be). It became clear that nobody had been minding the store.

The next brush fire involved Taiwan, which vigorously denied a rumor it was about to go in for plutonium separation.

Congress responded to all this with an outburst of speeches, resolutions, bills, and amendments to bills. These focused on the inherent dangers of plutonium stockpiling; on the ambiguities about explosives in our agreements (India and several other countries persist in their view that so-called "peaceful" nuclear explosives bear no relation to nuclear weapons); and on the fact that lack of specific licensing criteria was having an unfortunate effect on the implementation of our international arrangements — in short, on the need to tighten up.

Congressional attempts at legislation in 1976 all failed, often for reasons unrelated to their intent, in the final hectic days of the pre-election session. Nevertheless, there is no longer any question about the sense of the Congress: effective protection against the spread of nuclear weapons must be provided. In August, the President re-

sponded with the appointment of a study team to reexamine U.S. policies on proliferation, and this action resulted in the statement I mentioned at the outset.

The Myth of "Reactor-Grade" Plutonium

I should like to digress at this point to make some technical remarks about plutonium — the reactor-bred element which is causing most of the difficulty.

Plutonium can be fissioned slowly in a reactor. It is thus a potentially valuable fuel; it is central to the fueling of the breeder reactor.

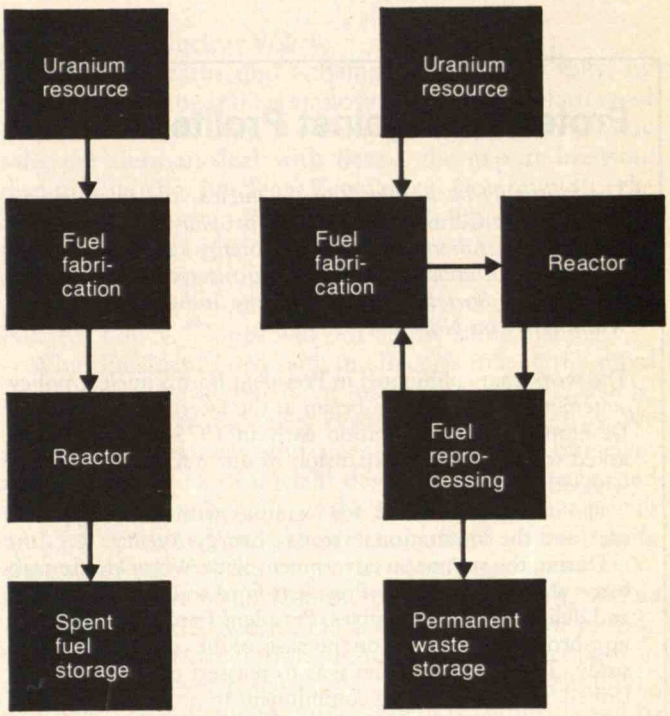
It can also be fissioned rapidly as a nuclear explosive. No way has yet been found to neutralize this characteristic.

There is an old notion, recently revived in certain quarters, that so-called "reactor-grade" plutonium is not suitable to the manufacture of nuclear weapons. The floating of this idea is perhaps a natural move by those who want to exclude plutonium from strict controls. A recent statement on nuclear exports by the Atomic Industrial Forum, for example, attempts to calm fears of proliferation by suggesting commercial power has no relation to it: "In establishing nuclear export policies it should be recognized that power reactors are not a practical or economic vehicle for producing weapons-grade plutonium."

The statement argues that in order to produce weapons-grade plutonium a power reactor must be run at low irradiation levels, which is uneconomic in a power plant, and that to do so would in itself be suspicious ("revealing of intentions," is the way they put it), bringing down the sanction of a cut-off in the plant's fuel supply. The statement claims that "the use of reactor-grade plutonium of high irradiation levels for weapons purposes presents formidable technical challenges."

The obvious intention here is to create the impression there is nothing to fear from separated plutonium derived from commercial power plants. This is not true.

The fact is that reactor-grade plutonium may be used for nuclear warheads at all levels of technical sophistication. In other words, countries less advanced than the major industrial powers but nevertheless possessing nuclear power programs can make very respectable weapons. And, I might add, these are the very countries whose names turn up in every discussion of proliferation. The use of reactor-grade plutonium may impose a penalty in performance that is considerable or insignificant, depending on the weapon's design. But whatever we might once have thought, we now know that even simple designs, albeit with some uncertainties in yield, can serve as



Uranium fuel for today's nuclear reactors contains the common isotope uranium-238 and an enriched fraction of the fissionable isotope uranium-235, which is the primary fuel. As uranium-235 fissions in the reactor, a small fraction of the accompanying uranium-238 is converted to plutonium, which also begins to fission. Some of this plutonium and some unfissioned uranium-235 remain in the spent fuel when it is withdrawn for replacement. Under present practice, this spent fuel is placed in storage according to the fuel cycle shown at the left.

The alternative, shown at the right, is to reprocess this spent fuel to recover its uranium-235 and plutonium for use in new fuel, committing the high-level radioactive wastes from this reprocessing to permanent storage. Recovery of uranium and plutonium in this way would reduce by 25 per cent the demand for fresh uranium-235.

The fast breeder reactor, which is the subject of a major commitment by the Energy Research and Development Administration, would use the more abundant isotope uranium-238 as a primary fuel and would produce more fissionable plutonium out of this uranium that it consumes. Hence the vision of a future system of reactors based on the fission of uranium-238 and plutonium. — *J.M.*

effective, highly powerful weapons — reliably in the kiloton range.

Unfortunately, the I.A.E.A. itself does not seem to have been entirely clear about this, and a number of non-nuclear states have raised questions about it. It is vitally important to serious attempts to stop further proliferation that any genuine confusion or misapprehension abroad about whether effective nuclear weapons can be manufactured with plutonium from power reactors be cleared up promptly. Such misapprehensions do exist; I encountered them myself recently in meetings with high officials in Europe. This is bad enough, but it is deeply disturbing to encounter irresponsible encouragement of such notions at home. For it will never be possible to discourage national reprocessing if it is believed that the United States is faking the dangers.

"Safeguarding" the Unsafeguardable

International action to control dangers of proliferation associated with the civilian nuclear fuel cycle depends critically on understanding two facts: first — the point we have just discussed — that nuclear weapons can be manufactured from reactor-grade plutonium; and second, that for any nation that has done its homework, separated plutonium — in either metallic or oxide form — can be suddenly appropriated from its storage place and inserted in warheads within days. A recent I.A.E.A. document acknowledges this latter point. It concludes that the safeguards system for plutonium facilities must be able to function on the same time-scale as it now does for reactors. The Agency does not appear, however, to have seen the vital implications of these facts, which is that separated plutonium is not safeguardable by any means now

Protection Against Proliferation

The following background on the nuclear policy statement by President Gerald R. Ford was provided by Robert C. Seamans, Jr., Administrator of the Energy Research and Development Administration, to a joint meeting of the American Nuclear Society, and the Atomic Industrial Forum in Washington on November 15, 1976:

The work that culminated in President Ford's nuclear policy statement of October 28 began at the Energy Research and Development Administration early in 1975 when we were asked to consider the expansion of our nuclear agreements with other nations.

Discussions were held, for example, with Iran, Egypt, Israel, and the International Atomic Energy Agency.

During the summer a government-wide White House task force was established by President Ford to define the issues and delineate the alternatives. President Ford announced his non-proliferation policy on the basis of the conclusion of this study. The President's aim was to reassert emphatically the United States' overriding commitment to preventing nuclear proliferation. Briefly, his eight-point program includes:

1. Commercial reprocessing of nuclear fuel in this country, which results in separation of plutonium, is being deferred until we can be certain it is consistent with our non-proliferation objectives.
2. Supplier nations are being asked to suspend exports of reprocessing and enrichment facilities or technology for at least three years.
3. Supplier nations also are being asked to assure their customers that adequate nuclear fuel will continue to be provided to them *if* they forego acquisition of reprocessing and uranium-enrichment capabilities and accept effective proliferation controls.
4. The United States is standing by its commitments of nuclear fuel to its own customers.
5. All nations should redouble their efforts to prevent proliferation.
6. The United States is tightening control of its own nuclear exports and pressing for improvements in multilateral guidelines.
7. The United States is undertaking a reprocessing and recycle evaluation program to determine whether such activities are consistent with our international objectives.
8. The United States is accelerating its program to demonstrate the technology for storage and disposal of nuclear wastes.

A special E.R.D.A. task force has been established under the direction of Dr. Richard Roberts to begin implementation of the President's program. We have already asked our government laboratories to see if they can devise new technology for the recovery of the energy value in used nuclear fuel without extracting the plutonium. For the longer term, we are also exploring alternative designs for proliferation-proof power reactors.

We are also moving to expand enriched uranium production at our government-owned plant in Portsmouth, Ohio.

We must have increased enrichment capacity to satisfy fully our national and international commitments while keeping tails assays at reasonably low levels. It is essential that we husband our uranium resources until the back end of the fuel cycle is clearly defined.

On waste management, Congress has provided a four-fold increase in funds and the President has directed a speed-up in E.R.D.A.'s demonstration program and set deadlines for its completion: all components of waste management technology will be undergoing test by 1978, and a complete underground repository is to be in place by 1985. This repository must be capable of storing spent fuel elements from commercial plants as well as the separated and solidified wastes that would result if nuclear fuel reprocessing were resumed.

The President's emphatic assertion of maximum prudence in fuel-cycle operations should not shake the nuclear industry's confidence in the future of nuclear power in this country or abroad. There remains the same strong belief in the wisdom of expanding our reliance on nuclear power to supply our energy requirements in the decades ahead. It is gratifying to learn from the recent referenda that in each instance where the general public has spoken, there has been emphatic support of the need for nuclear power.

These recent decisions are not intended to have any effect on E.R.D.A.'s breeder program. We will not know until the mid-1980s whether the breeder reactor technology, based on plutonium, is suitable for full-scale commercial exploitation. This time scale is consistent with the target dates for our reprocessing and recycle evaluations and for our waste management program.

Great diligence will be required to coordinate policies of the world's nations to prevent proliferation. But given the looming requirements for new energy sources worldwide, we must at the same time work toward a healthy expansion of nuclear power production for peaceful purposes.

available to us. We cannot count on warning in time to head off an illicit weapons effort.

Ironically, the principle of deterrence through early warning is basic to the International Atomic Energy Agency's system and appears in almost every U.S. official pronouncement on the purpose of nuclear safeguards; but the inherent problem with this is seldom faced up to: if the discovery doesn't take place early enough to allow for significant action to be taken, you don't have a very good deterrent. This is particularly true for example, where the sudden appropriation of safeguarded plutonium stockpiles is concerned, as the material at this stage is almost bomb-ready and the final steps can be only a matter of days.

Can the Agency, however, be expected to acknowledge these facts when its leading members have implicitly attested to the safeguardability of this material? During this past year the nuclear suppliers — brought together at the initiative of the United States — agreed among themselves on what are characterized as "very strict" safeguards over plutonium separation facilities such as those being sold by France and Germany to two non-signatories to the Nonproliferation Treaty — Pakistan and Brazil. On the basis of subsequent approval of the tripartite FRG-Brazil-I.A.E.A. and France-Pakistan-I.A.E.A. safeguards agreements by the I.A.E.A.'s Board of Governors, our own representative included, the I.A.E.A. inspectorate is proceeding with plans to "safeguard," despite the fact that even a perfect inspection and alarm system cannot provide adequate time for international action to head off the arming of nuclear weapons.

There is no escape from the fact that any nation with a store of separated plutonium is a nation with a nuclear weapons option — an option that can be picked up at will and on short notice. If sovereign nations are to be denied this easy option, some way has to be found to deal with national rivalries and the security concerns they engender.

I have never been very impressed when nations contend the answer to their security lies in superpower disarmament. I am more impressed by the obvious fact that they would be more secure if their neighbors didn't develop nuclear weapons. And that implies restricting access to the essential nuclear explosives, plutonium and highly enriched uranium — a restriction that can only be accomplished by some kind of international collaborative scheme. Unfortunately, the original U.S. pursuit of this objective has gradually become entangled with conflicting and self-defeating policies.

There is obviously inherent conflict between the development we were pushing so vigorously — with the breeder at the end of the line — and strict controls over what individual countries regarded as the great economic potential of the breeder's plutonium fuel. This conflict tended to be resolved by an easing of U.S. controls and increased reliance on the I.A.E.A.'s inspection system. Deficiencies in that system could not be acknowledged without jeopardizing expensive programs.

To raise questions about these and other matters is to offend the safeguards cult which has grown up over the years. Any unease about how well safeguards were working has been put down as damaging to the efforts to build up their acceptability worldwide. Doubts about the wisdom of nuclear exports to unstable countries or regions have been met with a frequent official response that the introduction of safeguards in such situations made the risk worth taking. In fact, safeguards have taken on a life of their own. Any opportunity to spread the gospel of safeguards among the unbelievers — those reluctant, for example to foreswear nuclear weapons by signing the Nonproliferation Treaty — actually appears, in some cases, to be the rationale for a nuclear export.

Now that the old rationales are finally starting to unravel, the nuclear bureaucracy and the industry argue that if there are flaws in the system it is too late to tighten up. If the spread of plutonium risks proliferation, it is probably inevitable in any case. If we don't export, even with less-than-optimal safeguards, somebody else will export with none. Because of the competition in nuclear sales we ourselves created, it is said the U.S. has lost its leverage over controls. In my view our ability to influence events has been greatly underestimated; the fact is that until now there has been little inclination to alter the status quo.

A Change in Nuclear Policy

But now the status quo is being altered, willy nilly, by such events as the Indian explosion and the revelations of U.S. involvement in it, the Pakistan-French reprocessing sale, the German deal with Brazil, the export licensing disputes in the Nuclear Regulatory Commission, the legislative activity in the Congress, the emphasis by President Carter on nuclear issues in the national election campaign, the growing interest in multinational fuel cycle centers, and the issuance of President Ford's Statement on Nuclear Policy. Things will not be the same again.

What President Ford said, in effect, is that in the rapid and essential development of nuclear energy worldwide, we have been getting dangerously ahead of ourselves. We have been, carelessly and needlessly, locking ourselves into a single track of nuclear development. He suggested that without any penalty to the success of nuclear power and its continued growth we can afford to stop long enough to take stock, assess the alternatives, and make sure our pursuit of nuclear energy is not precipitating us into a proliferated world. He was dubious about putting plutonium into circulation prematurely by recycling it in our present power reactors, " . . . reprocessing shouldn't proceed," he concluded "unless there is sound reason to conclude that the world community can effectively overcome the associated risks of proliferation."

The policy statement proposed a consolidation of position in such matters as the disposal of radioactive wastes and the storage of spent fuel to allow for either contingency: reprocessing or no reprocessing. It pointed out that the time to decide on commercial use of the breeder is still ten years away, a time sufficient to allow for the development of colloborative solutions to the problems it will present.

Mr. Ford also indicated an awareness and concern for the feeling which is growing in some parts of the world that the United States is crying wolf about proliferation and the dangers of plutonium in order to maintain commercial advantage in the nuclear marketplace. To avoid such suspicion, he said our domestic and international policies with regard to reprocessing must be consistent, and pleaded that, if it comes to a choice, "all nations recognize that the United States believes that nonproliferation objectives must take precedence over economic and energy benefits."

The Search for Common Standards

Looking back, it is difficult to avoid the feeling that we

have come very close to cornering ourselves. What is to be done now?

It is essential, but it isn't enough, to put our own house in order.

A larger problem, more difficult, is how to introduce some international order into the exploitation of nuclear energy. It should be remembered that in 1946 the United States, in the conviction there was no other way to solve the problem, offered to give ownership and management of nuclear materials over to an international authority. President Ford's Statement on Nuclear Policy implies a return to that earlier awareness that unrestricted national development of nuclear power programs is inherently incompatible with a secure world. And in this sense the climate in which solutions will be sought has been altered.

But the real question now will be how much will be built on the White House program outlined in October. In the area of U.S. nuclear export policy, the need for more vigorous control was acknowledged, but no definite steps were taken. New criteria for judging nuclear corroboration were announced: adherence to the Nonproliferation Treaty or, lacking that, to comprehensive I.A.E.A. safeguards. (The I.A.E.A. Director-General recently urged supplier states to require "as an irrevocable condition for the delivery of nuclear material or equipment, that the receiving state accept I.A.E.A. safeguards on its entire nuclear programme." The Nonproliferation Treaty requires such comprehensive safeguards. The reference here, of course, is to non-signatory nations.) Additional criteria include foregoing or at least delaying construction of sensitive fuel cycle facilities, and participation in international nuclear fuel storage schemes.

But President Ford's criteria applied only to new or expanded agreements, and even then the application was not clear: countries meeting these criteria were to receive "positive recognition," or the like, and exceptions to the criteria were explicitly provided for. Current trading partners were to be approached to see whether they were willing to renegotiate agreements to conform with new criteria. This poses complex and delicate problems, and the success of such efforts will depend critically on how far beyond the permissive guidelines of the past administration the new team at the Department of State is willing, or able, to go. One thing is plain: achievements of the nonproliferation objective laid down by Presidents Ford and Carter will require some very hard choices, sometimes involving our alliances as well as our commerce.

President Ford rightly said that action "to control pro-

". . . the reprocessing and recycling of plutonium should not proceed . . ."

Following are excerpts from the statement on "Nuclear Policy" issued by President Gerald R. Ford on October 28, 1976:

We have known since the age of nuclear energy began more than 30 years ago that this source of energy had the potential for tremendous benefits for mankind and the potential for unparalleled destruction.

On the one hand, there is no doubt that nuclear energy represents one of the best hopes for satisfying the rising world demand for energy with minimum environmental impact and with the potential for reducing dependence on uncertain and diminishing world supplies of oil.

On the other hand, nuclear fuel, as it produces power also produces plutonium, which can be chemically separated from the spent fuel. The plutonium can be recycled and used to generate additional nuclear power, thereby partially offsetting the need for additional energy resources. Unfortunately — and this is the root of the problem — the same plutonium produced in nuclear power plants can, when chemically separated, also be used to make nuclear explosives.

The world community cannot afford to let potential nuclear weapons material or the technology to produce it proliferate uncontrolled over the globe. The world community must ensure that production and utilization of such material by any nation is carried out under the most stringent security conditions and arrangements.

Developing the enormous benefits of nuclear energy while simultaneously developing the means to prevent proliferation is one of the major challenges facing all nations of the world today.

The standards we apply in judging most domestic and international activities are not sufficiently rigorous to deal with this extraordinarily complex problem. Our answers cannot be partially successful. They will either work, in which case we shall stop proliferation, or they will fail and nuclear proliferation will accelerate as nations initially having no intention of acquiring nuclear weapons conclude that they are forced to do so by the actions of others. Should this happen, we would face a world in which the security of all is critically imperiled.

* * *

The seriousness and complexity of the problem place a special burdon on those who propose ways to control proliferation. They must avoid the temptation for rhetorical gestures, empty threats, or righteous posturing. They must offer policies and programs which deal with the world as it is, not as we might wish it to be. The goal is to prevent proliferation, not simply to deplore it.

* * *

No single, nation, not even the United States, can realistically hope — by itself — to control effectively the spread of reprocessing technology and the resulting availability of plutonium.

The United States once was the dominant world supplier of nuclear material equipment and technology. While we remain a leader in this field, other suppliers have come to share the international market — with the U.S. now supplying less than half of nuclear reactor exports. In short, for nearly a decade the U.S. has not had a monopoly on nuclear technology. Although our role is large, we are not able to control worldwide nuclear development.

For these reasons, action to control proliferation must be an international cooperative effort involving many nations, including both nuclear suppliers and customers. Common standards must be developed and accepted by all parties. If this is not done, unrestrained trade in sensitive nuclear technology and materials will develop — with no one in a position to stop it.

* * *

Last summer, I directed that a thorough review be undertaken of all our nuclear policies and options to determine what further steps were needed. I have considered carefully

liferation must be an international cooperative effort involving many nations" and that this in turn means the acceptance and adoption of "common standards." The statement pointed out that we have lost our monopoly over nuclear technology and equipment. At the same time, it placed great emphasis on maintaining the supply of enriched fuels so essential to the operation of reactors built with that technology and equipment. (In this context, it is relevant to note that over 90 per cent of the enriched uranium imported into the European Economic Community in 1975 came from the United States.)

The fact is that the major part of the plutonium we are worried about has come, and will continue for a valuable period of time to come, from fuel supplied by this country. Our concern about its disposition will have to be taken into account as we work internationally towards the acceptance and adoption of "common standards."

In my view nuclear commerce must be conditioned on a common understanding that certain activities are inherently dangerous, cannot be safeguarded when conducted on a national basis, and must therefore be collaboratively managed.

As a prerequisite to nuclear trading, there must be an explicit, common understanding that no distinction can be recognized between military and so-called "peaceful" nuclear explosives.

In addition, common standards have to include comprehensive international oversight of all nuclear activities in any country receiving nuclear material or equipment. The most satisfactory way to achieve this, of course, is through adherence to the Nonproliferation Treaty.

Finally, and most important, we have to treat common standards as collectively binding. There are great dangers in building a regime around procedures riddled with exceptions to be taken under political or economic expediencies of the moment. That is how we got into the situation which confronts us today.

Before his recent appointment to the Nuclear Regulatory Commission, **Victor Gilinsky** was Head of the Physical Science Department at Rand Corp. and Assistant Director of Policy and Program Review for the Atomic Energy Commission. He joined Rand Corp. in 1961 upon completing his doctorate in theoretical physics at the California Institute of Technology. This article is based on a paper prepared for presentation to a seminar of the Department of Nuclear Engineering at M.I.T. on November 1, 1976.

the results of that review, held discussions with congressional leaders, and benefited from consultations with leaders of other nations. I have decided that new steps are needed, building upon the progress of the past two years. Today, I am announcing a number of actions and proposals aimed at:
— strengthening the commitment of the nations of the world to the goal of nonproliferation and building an effective system of international controls to prevent proliferation;
— changing and strengthening U.S. domestic nuclear policies and programs to support our nonproliferation goals; and
— establishing, by these actions, a sound foundation for the continued and increased use of nuclear energy in the U.S. and in the world in a safe and economic manner.

* * *

I have concluded that the reprocessing and recycling of plutonium should not proceed unless there is sound reason to conclude that the world community can effectively overcome the associated risks of proliferation. I believe that avoidance of proliferation must take precedence over economic interests. I have also concluded that the United States and other nations can and should increase their use of nuclear power for peaceful purposes even if reprocessing and recycling of plutonium are found to be unacceptable.

Vigorous action is required domestically and internationally to make these judgments effective.

I have decided that the United States should greatly accelerate its diplomatic initiatives, in conjunction with nuclear supplier and consumer nations, to control the spread of plutonium and technologies for separating plutonium.

Effective nonproliferation measures will require the participation and support of nuclear suppliers and consumers. There must be coordination in restraints so that an effective nonproliferation system is achieved, and there must be cooperation in assuring reliable fuel supplies so that peaceful energy needs are met.

I have decided that the United States should no longer regard processing of used nuclear fuel to produce plutonium as a necessary and inevitable step in the nuclear fuel cycle, and that we should pursue reprocessing and recycling in the future only if they are found to be consistent with our international objectives.

We must ensure that our domestic policies and programs are compatible with our international position on reprocessing and that we work closely with other nations in evaluating nuclear fuel reprocessing.

The steps I am announcing today will assure that the necessary increase in our use of nuclear energy will be carried on with safety and without aggravating the danger of proliferation.

* * *

My decisions today do not affect the U.S. program of research and development on the breeder reactor. That program assumes that no decision on the commercial operations of breeder reactors, which require plutonium fuel, will be made before 1986.

* * *

I do not underestimate the challenge represented in the creation of a worldwide program that will permit capturing the benefits of nuclear energy while maintaining needed protection against nuclear proliferation. The challenge is one that can be managed only partially and temporarily by technical measures.

It can be managed fully if the task is faced realistically by nations prepared to forego perceived short-term advantages in favor of fundamental long-term gains. We call upon all nations to recognize that their individual and collective interests are best served by internationally assured and safeguarded nuclear fuel supply, services, and storage. We ask them to turn aside from pursuing nuclear capabilities which are of doubtful economic value and have ominous implications for nuclear proliferation and instability in the world.

The growing international consensus against the proliferation of nuclear weapons is a source of encouragement. But it is certainly not a basis for complacency.

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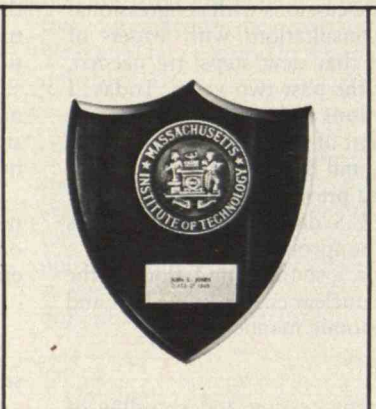

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Back to the Lesser Antilles

Puzzle Corner
by
Allan J. Gottlieb

Since I am usually the first (and often the only) person to mention any favorable reviews that "Puzzle Corner" receives, let me mention an interesting complaint. Sharon M. Fester is unhappy with M/A SD 1 for "bringing sexism into a probability and statistics problem" by using terms like "the Old Maid Theory."

I can honestly plead innocent to any charges of chauvinism in my personal life, but — perhaps due to insufficiently raised consciousness — I never gave this much thought with regard to "Puzzle Corner." A perusal of the "offending" issue reveals a man rescuing a drowning girl, a boy asking a girl to marry him, and a keyword "Techalumni," in addition to the example with which Ms. Fester is unhappy. So her complaint is perhaps well grounded.

It is certainly true that the same mathematical questions could have been posed in neutral terms. There is a danger, however, that such a rewording would remove a little of the charm of these questions and move them slightly away from puzzles, toward problems.

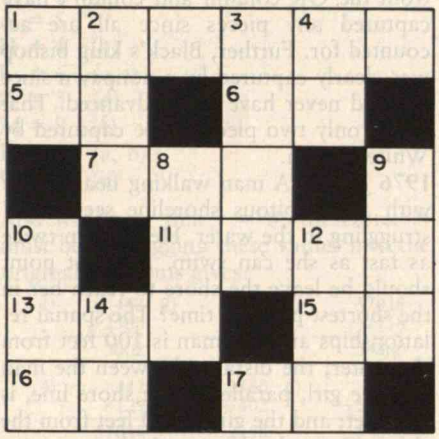
What do you think? I'm especially interested in the opinions of the many women who read and contribute to this column.

Problems

NS6 We begin this month with an old problem (March, 1970) whose solution was never printed. The problem was later revised (June, 1970), and — due to an error on my part — no solution was printed although solutions were listed as Better Late Than Never. So this is likely to be comparatively easy for a "never-solved" puzzle. The revised problem, from Lawrence S. Kalman, follows:

So many of our friends have asked about the boat in which we cruised the Lesser Antilles, and about the crew, that we have prepared a diagram which answers most of their questions.

The crew of five were the skipper, first mate Joseph, navigator Peter, deck hand Moses, and cook Able. They all voted for Eisenhower. The total miles shown on the taffrail log was twice the number for the first nine days plus exactly 200 miles. However, we had the log carefully



checked and found that for each mile registered we had sailed 6,120 feet, so the distance sailed was slightly greater than that shown on the log. As to the crew, it so happened that if Peter had been 14 years older the skipper would have been twice the average age of his crew. Also if the skipper had been 13 years older his age would have equaled the sum of the ages of the three youngest members of the crew. The dimensions of the boat, sail area, and ages of crew can now be easily ascertained by completing the above diagram and using the following clues.

Across

1 Yards sailed in nine days
5 Age of first mate
6 Twice the age of Joseph
7 Miles logged in nine days minus 1 down
11 Square of 4 down minus 2 down
13 Total miles logged
15 Age of Moses
16 Length overall
17 1 down reversed

Down

1 Cube of beam in yards or square of draft in feet
2 Miles logged in nine days
3 Area of mizzen times beam
4 Two times 5 across
8 Length overall times draft
9 Area of mainsail or twice area of mizzen plus sum of digits of 11 across
10 Area of mainsail plus length overall
12 Low water length plus length overall plus draft plus beam
14 Age of Able

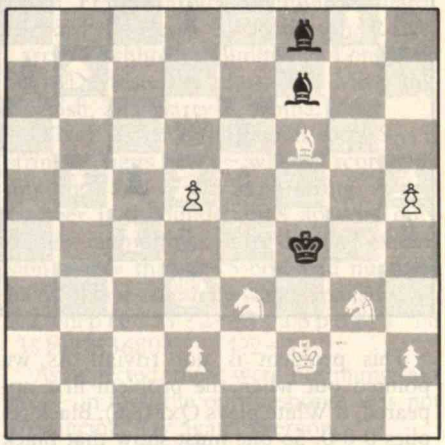
Another clue: the problem was concocted some years ago.

NS5 When this problem first appeared in the December issue a noncritical paragraph was omitted. Here is the entire problem:

Since most people find the geometry problems the easiest, I have decided to print one which appears to me to be rather formidable. Should the wording sound a little strange, bear in mind that it comes from Mr. Fine of Gloucester, England; he admits that it may be "too advanced" for the *Review*! And he also says that "though it is fairly easy to find special cases (e.g., a recurrent sequence), I have not really 'got my teeth' into this problem — which is well over 20 years old."

If a pair of triangles is not copolar, the joins of corresponding vertices form a triangle and so do the intersections of corresponding sides. The original pair of triangles has been transformed into a second pair which can be transformed into a third and so on. How does the sequence of pairs of triangles behave?

FEB 1 Our first regular problem this month, from Michael Laufter, is another White to mate in two. Unlike **1975 June 1** (see solutions, below), Mr. Laufter's problem is quite "normal":



FEB 2 Judith Q. Longyear, perhaps noting the rise in women's athletics, asks the following:

The 11 footballers of Croam play five-on-a-side matches against each other, the 11th footballer being referee. One match is played with each possible choice of teams and referee. Can you schedule the 1,386 matches so that each individual team plays its six matches on six different

days of the week? Note that in Croam one does as the Croamans do, so the schedule must be set up in such a way that matches are played never on Sunday. (Dr. Longyear should not be held responsible for the wording of the last sentence. — Ed.)

FEB 3 Patricia Lougheed wants you to solve

$$\begin{aligned} x_1 + x_2 + x_3 &= a^2 \\ x_1 + x_2 + x_4 &= b^2 \\ x_1 + x_3 + x_4 &= c^2 \\ x_2 + x_3 + x_4 &= d^2 \end{aligned}$$

where each symbol is an *integer* and the four x's are unique.

FEB 4 Mickey Haney needs, for all $N > 0$, N positive integers (not necessarily distinct) whose sum and product are equal.

FEB. 5 Can Robert Mills construct a 4x4x4 magic cube (equal sums along horizontals, verticals, in-outs, and diagonals) consisting of 64 distinct numbers?

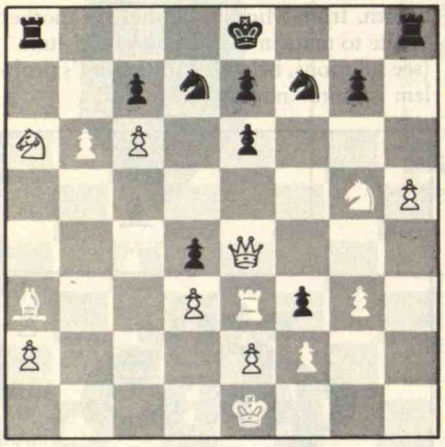
Speed Department

SD 1 Emmet J. Duffy asks what (nonarchaic) English verb has no infinitive.

SD 2 The following is from James Shearer: A daily calendar B to be made by putting numbers on the faces of 2 cubes, so that all the dates of the month can be indicated by appropriate rotations of the cubes [01, 02, . . . 29, 30, 31]. (Note that zero is included). How should the integers be arranged on the two cubes?

Solutions

1975 JUN 1 White to move and mate in two:



This problem is not trivial! As we pointed out when the problem first appeared, if White plays QxP(K6), Black replies 0-0-0. So one must show that Black cannot castle queenside. I suspected that a key was the fact that Black's king bishop could not have moved. J. F. Chandler used this fact to prove the whole position impossible and concluded that the problem was in error. But just five minutes ago the solution hit me! Chandler proved that the position is impossible if Black moves *down* the page. Thus Black moves up the page, the position is legal, Black has moved his king and can't castle, and the mate is given by QxP (Q3!!!), any; Q mates on *second* rank. Gotcha, Mr. Nelson (I think). Mr. Chandler's comments follow:

The situation is still impossible as follows: White has now lost three pieces, but Black's pawns need to have captured three to reach this position (e.g. P at Q4 taking two and P at K6 taking one). So White's only missing pawn must have been captured by a pawn and (to allow Black to stack pawns thus with only three captures) at least as far left as the king. That means White's pawn or pawns must have captured at least three Black pieces from the right-hand 5/8 of the board. However, Black's missing pawn must have come from the QR column and couldn't have captured any pieces since all are accounted for. Further, Black's king bishop was clearly captured by a nonpawn since it could never have been advanced. That leaves only two pieces to be captured by White's pawn.

1976 JUN 5 A man walking near a lake with a precipitous shoreline sees a girl struggling in the water. He can run twice as fast as she can swim. At what point should he leave the shore to reach her in the shortest possible time? The spatial relationships are: the man is 100 feet from the water; the distance between the man and the girl, parallel to the shore line, is 100 feet; and the girl is 100 feet from the shore. Ground rule: no calculus.

The following solution is courtesy of Gene Bedal, who admits that "the girl surely drowns if her rescue depends upon my coming up with an answer": The answer is 70.0535 ± 0.00005 feet as measured from a perpendicular from my position. Failing to find a neat equation with the distance wanted, x, on one side, I used a surveying method called "wiggling-in," essentially trial and error, to find an x yielding the shortest value in the equation

$$k \cdot \text{time} = \sqrt{100^2 + x^2} - 2\sqrt{100^2 + (100 - x)^2}.$$

Although use of calculus was disallowed, I tried it for check (while they were dragging for the girl's body). But an even more cumbersome equation results, as you know from taking the first derivative (best solution?). However, for anyone's interest, by similarly finding an x suitable in an equation identical to

$$x\sqrt{(a - x)^2 + a^2} = 2(a - x)\sqrt{a^2 + x^2},$$

result: $70.053453405 \pm 5.0^{-10}$ feet, by use of my TI SR-50A, which I always carry with me on my jaunts. It is assumed that the "precipitous slope" merely provides for an immediate transition from running to swimming and does not indicate a falling/leaping parameter.

Also solved by Carey Rappaport, John E. Prussing, James W. Shearer, R. Robinson Rowe, William J. Butler, Jr., Harry Zaremba, Richard Hess, R. Bart, Jeffrey Miller, Robert Pogoff, Charles Rozier, Glenn Loary, and the proposer, Jack Parsons.

O/N 1 Given the two hands and the bidding shown (both sides vulnerable), and the following first three plays, plan the balance of play. The opening lead was ♥3, won by East with ♥A; East returns ♥7 to West's ♥9; then West shifts to ♦3.

North
♠ J 7 3 2
♥ 6 2
♦ A K 8 7 6
♣ J 3

South
♠ A K 6 5 4
♥ 8 5
♦ 2
♣ A 10 6 5 4

South	*West*	*North*	*East*
1 club	—	1 diamond	1 heart
1 heart	3 hearts	3 spades	—
4 hearts	—	—	—

This must have been hard, as only three solutions were received. The following is from Winslow H. Hartford:

The hand loses the first two heart tricks and must lose a club. For the contract, therefore, declarer must take five trump tricks, two club ruffs, the ♣A, and the ♦A and ♦K. This is easily managed if the trumps break two-to-two; and there are other, remoter, possibilities. In any event, take ♦A and lead to ♠A. The ♠Q is singleton. Now North's ♠J will be needed to prevent the loss of a spade trick. Only one club ruff can be secured, so clubs must break three-to-three. This first strategy has approximately a .375 chance of success. The second strategy has a chance of .125 that the ♠Q is singleton. If the ♠Q drops, then clubs must be tested. The best strategy is to give up a club, and the best defense is a trump return. (You get a little extra if a trump is not returned.) Win the trump with the ♥J. Return to hand by ruffing a diamond (almost reckless), then a club to dummy (ruffing). Play succeeds (a) if clubs are three-to-three (.375) or (b) if the player with the last trump has four clubs (.125). In case (a), cash ♦K, return to hand with ♠K, and cash established clubs. In case (b) there are entry problems and the almost sure incidence of a diamond ruff, so the successful ruffing of the third club is fruitless. The total chance of success in the hand approximates .375 − .125 · .375, or 4219 (I have used binomial probability for simplicity).

Also solved by R. Robinson Rowe and Richard I. Hess.

O/N 2 The proposer, Magne Wathne, noticed that 9/1 = 9, 98/12 = 8.166 . . . , and 987/123 = 8.024. . . . He then found patterns for the numerator and denominator which begin with the three given and result in fractions which approach 8. What are those patterns?

I present below an amalgamation of several responses:

The numerator of the nth term is

$$\sum_{i=1}^{n} (10 - 1)/10^i = .9 + .08 + \ldots + .000000001 + 0 - .00000000001 + \ldots$$

and the denominator is

$$\sum_{i=1}^{n} (i/10^i = .1 + .02 + \ldots + .000000009 + .0000000010 + .00000000011 + \ldots)$$

It turns out that the numerator is a nine-digit repeating decimal .987654320987654320 . . . and the denominator is a similar repeating decimal .123456790123456790 . . . The important points are that by summing geometric series

$$\sum_{i}^{\infty} 1/10^i = 1/9$$

and

$$\sum_{i}^{\infty} (i/10^i = (1/10 + 1/10^2 + 1/10^3 + \ldots) + (1/10^2 + 1/10^3 + \ldots) + (1/10^3 + \ldots) = 1/9 + 1/10 \cdot 1/9 + 1/10^2 \cdot 1/9 + \ldots = 1/9\,(1 + 1/10 + 1/10^2 + \ldots) = 1/9\,(10/9) = 10/81.$$

Hence

$$\frac{\Sigma \frac{10\text{-}i}{10^i}}{\Sigma \frac{1}{10^i}} = \frac{10 \Sigma \frac{1}{10^i} - \Sigma \frac{i}{10^i}}{\Sigma \frac{1}{10^i}} = \frac{10\left(\frac{1}{9}\right) - 10/81}{10/81} = 8$$

Responses received from John F. Chandler, Judith Q. Longyear, R. Robinson Rowe, Harry Zantopulos, Winslow H. Hartford, R.I. Hess, and the proposer.

O/N 3 A cross-metric:

HHE	×	TEN	=	AUITM
+		×		−
EALI	−	HIE	=	ETAM
=		=		=
CIIE	+	ATMAM	=	AHMLI

Even a typo doesn't slow our readers down. The following solution is from Linda Eckstein:

Setting this up in an easier to read format gives:

1)	2)	3)
HHE	TEN	AUITM
+EALI	×HIE	−ETAM
CIIE	ATMAM	AHMLI

4)	5)	6)
HHE	EALI	CIIE
×TEN	−HIE	+ATMAM
AUITM	ETAM	AHMLI

On initial examination of letter relationships I is obviously equal to 0 [M − M in (3) or E + I = E, I = 0 in (1)]. By examining further, the following relationships can be set up:

a) E + M = 10 (5, 6)
b) E × N = 10^x + M (2, 4)
c) 1 + A = L (5, 6)
d) C + T = H (6)
e) U − 1 − E = H (3)
f) 9 − T = M (3)
g) T + 10 − A = L (3)
h) A − H = T (5)
i) H + L = 10 (1)

By further examination and substitution, two important equations are determined: Equation one:

L = A + 1 = T + 10 − A (c, g)
therefore: 2A = T + 9 or T = 2A − 9 and T is determined to be odd.
Equation two:
H = C + T = A − T (d, h)
therefore: A − C = 2T. We know that A-C is even, and must be ≤8, and because T is odd, T is either 1 or 3. Then from equation one we know that if T is 1 then A is 5, and that if T is 3 then A is 6. By plugging these values in the above equations (a thru i), we find in equation h that if T is 3 and A is 6, A − H = T or 6 − H = 3, or that H = 3. But H cannot equal T. Therefore T must be 1, and A must be 5. Further plugging in of values gives:

T = 1
A = 5
H = 4 (h)
L = 6 (c, i)
C = 3 (d)
M = 8 (f)
E = 2 (a, b)
U = 7 (e)

And we know that I = 0; therefore, N must be 9. Plugging these values into the original problems gives:

1)	2)	3)
442	129	57018
+2560	×402	−2158
3002	51858	54860

4)	5)	6)
442	2560	3002
×129	−402	+51858
57018	2158	54860

The code, in digital order, spells TECHALUMNI.

Also solved by Harry Hazard, Winslow H. Hartford, Bill Swedish, Ted Mita, R. Bart, Scott Davidson, Richard Early, Larry Wischoefer, Avi Ornstein, Harry Zaremba, Judith Q. Longyear, R.I. Hess, and the proposer, R. Robinson Rowe.

O/N 4 A offers to run three times around a course while B runs twice around, but A gets only 150 yards of his third round finished when B wins. He then offers to run four times around for B's thrice and now quickens his pace in the ratio of 4:3. B also quickens his in the ratio of 9:8 but in the second round falls back to his original pace of the first race and in the third round goes only nine yards for the ten he went in the first race, and accordingly this time A wins by 180 yards. Determine the length of the course.

I have previously published responses from readers in several continents. But I just received a letter from Brooklyn! Ah youth! Ah Ebbetts Field! Ah Reese, Campanella, Newcombe, Robinson . . . Ah shucks, Mr. O'Malley, why did you leave us?

The following solution is from Howard Ostar, a senior at Abraham Lincoln High School in Brooklyn:

Let x be the speed of A, y the speed of B, z the length in yards of one lap, and t the time required for B to travel z yards at y speed. The first race can then be written:

y (2t) = 2z
x (2t) = 2z + 150

Divide the first equation into the second:

x/y = (z + 75) / z

Now A goes four laps 4/3 as far as he was traveling. Merely to simplify, we can keep A at a speed of x to travel three laps. The answer will be the same for z. B increases his speed to 9/8 of his original, and since velocity is inversely proportional to time for a constant distance, his time to run his first lap will be 8t/9. We check how far A travels in the same time, and do the same for the second lap:

19y/8 * 8t/9 = yt = z
x * 8t/9 = 8xt/9 = 8/9 * (z + 75) = (8z + 600)/9
y * t = yt = z
x * t = xt = z + 75 = (9z + 675)/9

So far, B has traveled 2z yards, with (z − 180) yards to go (since he lost by 180 yards). A has run (17z + 1275)/9 yards, with (10z − 1275)/9 to go. We set c as the time needed for A and B to finish this distance for each man at his own speed (B having slowed down again). Then, as before, we divide the B-equation into the A-equation to get rid of c:

9y/10 * c = z − 180
y * c = (10z − 1800)/9
x * c = (10z − 1275)/9
x/y = (10z − 1275)/(10z − 1800)

For x/y, we substitute (z + 75)/z and cross-multiply:

$10z^2 + 750z - 1800z - 135{,}000 = 10z^2 - 1275$
$225z = 135{,}000$
$z = 600$

The length of the course is 600 yards.

Also solved by John E. Prussing, Winslow H. Hartford, Harry Zantopulos, Ed Chalfie, James Shearer, Carey Rappaport, Thomas Turnbull, M. Guerst, Fred Steigman, Carey Kaptur, George Flynn, Frank Carbin, Raymond Gaillard, Richard I. Hess, R. Robinson Rowe, Larry Wischhoefer, Judith Q. Longyear, Scott Davidson, R. Bart, Ted Mita, Bill Swedish, and Harry Zaremba.

O/N 5 A sentential digital form S is a string of digits ? and ~ where ? represents any digit and ~ any digit string. A real number is S-bounded if S appears only finitely many times in its decimal expansion. Show that the S-bounded numbers have (Haar or Lebesque) measure 0. Example: 1?2~3 appears in .351927536802 . . . 1?2~3.

As expected, there were not many takers — in fact, the only response was not convincing. Try again, everyone.

Better Late Than Never

MAY 2 Leon Bankoff submits the following, "more general" solution:

The problem lends itself to a simple solution by inequalities. Indeed, the proposal contains many redundancies. The segments h_1, h_2, r, s, t, u, v and w could

Continued on p. 71

Book Reviews

A Surfeit of Bright Young Things

Ph.D.s and the Academic Labor Market
Allan M. Cartter
New York: McGraw-Hill Book Co. for the Carnegie Commission on Higher Education, 1976, xviii + 260 pp.; $12.50

Reviewed by John D. Alden

Allan Cartter surely did not intend it, but his untimely death has left this book, the result of three years of concentrated study and analysis, as a legacy to the U.S. educational establishment. Like John the Baptist calling on the wayward to repent, Dr. Cartter has a reputation for being a voice crying in the wilderness, a prophet before his time. His well-reasoned warnings in the mid-1960s that a surplus of Ph.D.s was in prospect went largely unheeded, and his advice to the U.S. Department of Labor as Chairman of a Committee on Scientific and Professional Manpower in 1972 was ignored.

Now he has made another meticulous study of the historical data and the factors influencing supply of and demand for Ph.D.s, and concluded that the most likely scenario is a steady decrease in job opportunities reaching bottom between 1981 and 1985, when somewhere between 3 per cent and 17 per cent of the new graduates will be able to find openings in academia. The unfortunate majority not so hired will, in Dr. Cartter's view, stand a good chance of being underemployed although not out of work, for he believes that Ph.D.s "by-and-large ... are resourceful people who will find some form of employment." Dr. Cartter clearly hoped that his depressing prognosis would not come to pass, for he notes that "projections attempting to influence policy judgments are frequently self-denying if they are taken seriously."

This reviewer doubts that such will be the case. Dr. Cartter's book is, shall we say, not the easiest reading. A considerable part of it consists of tables of data and long discussions of imperfections in the data base and the relative likelihood of alternatives A,B,C,D, and E, within which the nuggets tend to be deeply buried. It is all too easy for the superficial browser to pluck out an impressive-looking table or graph without bothering to note that Dr. Cartter has produced it only to discard it later on in favor of a more sophisticated approach.

His policy recommendations are likely to be viewed by those to whom they are directed as no more appetizing than a dose of castor oil. The federal bureaucracy in the National Center for Education Statistics, the U.S. Department of Labor, and the National Science Foundation should admit the deficiencies in the programs of these agencies and start producing data that will be more relevant to the real job market? Hmm! College and university departments should warn students that job prospects in their fields are likely to be terrible? Hah! The professional societies must pick up the burden of collecting and disseminating data? Dr. Cartter himself says they clearly need government assistance in coping with the problem, and how likely is that to be forthcoming in these inflationary and egalitarian times? Finally, Dr. Cartter's own voice has been stilled, and there are few candidates with the experience or reputation to assume his mantle.

Statistical Pitfalls

Why worry about the academic labor market? Clark Kerr in a short introduction to the book explains why college presidents and trustees need to be constantly aware of its fluctuations in their concern for the quality of their faculties. He also deplores the wasted investment in dollars, time, and talent when highly educated people are not properly utilized, and laments how "it is tragic to encounter new Ph.D.s who started working for their degrees when their subject fields were booming only to finish them when the market for their training had all but disappeared." Finally, there is the need to understand the labor market when shaping national higher education policy.

Dr. Cartter's approach is extremely careful and detailed. He starts with basic demographic statistics and painstakingly seeks to verify their reliability, analyzes the factors affecting the labor market behavior of students and academic institutions, disaggregates and reassembles the data, postulates alternatives, and finally sets forth his own best judgment as to what the future will hold. If anyone thinks that the study of this specialized segment of national employment is simple, he will soon be disabused of the notion.

Dr. Cartter leads the reader step by step through the following: birth and fertility rates, the potential supply and age distribution of college entrants, student retention and attrition, the progression to higher degree levels, and the placement experience of graduates at the end of the pipeline. At each stage he examines such complicating factors as distortions in the past data, differences between men and women at each level, full-time versus part-time students; different trends in the junior colleges, four-year colleges, graduate schools, and professional schools; and potential future changes in these factors and trends. Having gone through this once on a "fixed coefficient" basis, he repeats his analysis with the introduction of "market response" factors and shows the effect of alternative assumptions at each decision point.

On the demand side he looks at ratios of students to teachers, again analyzing the different types of schools. Dr. Cartter also shows why incremental ratios are often more important than averages, and how small percentage changes in total enrollments are leveraged into major swings in the creation of new teaching jobs. For example, a 3 per cent increase in a total enrollment of 5 million would add 150,000 students and might call for 10,000 new faculty, whereas a 6 per cent increase would require 20,000 teachers or a 100 per cent difference in the demand for new Ph.D.s. The arithmetic is obvious and the effect of such swings on the prospects of a graduating class can be imagined, but there is probably little recognition of the fact that our national data collection programs are incapable of measuring such changes accurately or rapidly enough to detect major fluctuations in demand before they have happened.

Statistical pitfalls are many, as Dr. Cartter points out. He cites as an example the belief held almost universally by educators throughout the 1950s and early 1960s that there was a serious and growing shortage of Ph.D.s. This conclusion was drawn from National Education Association surveys that seemed to show a decreasing percentage of doctorates among new faculty hires. Dr. Cartter began to question the conventional wisdom when he realized that in no institution with which he was acquainted was the quality of the faculty actually deteriorating. Why then did everyone believe that this was happening? He found that the N.E.A. statistics had simply failed to account for faculty members receiving

their Ph.D.s after they had been hired! The percentage of doctorates among faculty members had actually been increasing all along. It was as if all the educators were going south when they thought they were heading north because they focused their attention on a reversed compass instead of watching the sun.

Dr. Cartter points out other gaps or weaknesses in national data. He suspects the validity of recent National Center for Education Statistics data because continuous retroactive revision of the numbers "not only makes it difficult for one to determine the real historic trend in average and incremental student-staff ratios, but also raises doubts about the reliability of the faculty data in the first place." If we don't have a reasonably accurate idea of where we have been and where we are now, how can we make an intelligent projection of where we are likely to be tomorrow? Dr. Cartter cites the changing Ph.D. projections issued for the 1974-75 period by the National Science Foundation in recent years. Taking the figures for engineering, a field with which this reviewer is most familiar, N.S.F. in 1969 projected 4,800, reduced this to 4,440 in 1971, and dropped the estimate further to 3,450 in 1975. The actual production of engineering doctorates for 1974-75 was 3,138. In another table, Dr. Cartter bases some of his own calculations on National Center for Education Statistics projections indicating that the number of B.S. degrees in engineering will increase by only 3 per cent from 1973-74 to 1983-84. He evidently was not aware of Engineering Manpower Commission data showing an increase of 45 per cent in freshmen enrollments from fall 1973 to fall 1975.

On the positive side, he praises the efforts of the physics profession to keep its members aware of changing supply-demand conditions. The American Institute of Physics, he says, "has placed truth and objectivity for their field above the parochial interests of their local departments," and he credits to this approach the fact that physics has become more market responsive than any other scientific field. He also gives the Engineering Manpower Commission a pat on the back for its "long tradition of manpower assessment."

Who Needs a Ph.D.?

Dr. Cartter comes up with other findings that are either contrary to common beliefs or have not been brought out elsewhere. For instance, his analysis of Ph.D. placement data leads him to conclude that academic job discrimination against women had disappeared by 1973 and that "academic institutions have successfully eliminated sex inequities in the job market for the current generation of young doctorate recipients." A similar conclusion can be reached on the basis of starting salary data for women in engineering, but most observers continue to cite crude, aggregated statistics in which recent trends cannot be described.

Another finding should be of special interest to engineering doctorate students. Data for 1973 (the latest available to Dr. Cartter) show that for all Ph.D. fields combined, 68.6 per cent of the graduates entered academic jobs. However, the percentage varied by field from a high of 91.7 per cent in English to a low of 27.7 per cent in engineering. Further, only 10.3 per cent of the engineering doctorates went into teaching. In other words, the greatest part of the job market for engineers holding Ph.D.s is outside academia, and even within the academic sector there are probably more positions in research than in teaching. This leads to the conclusion that even Dr. Cartter's prediction of future surpluses of Ph.D.s, while of serious concern in most fields, may have less import for engineering.

If there is one area where this reviewer would challenge Dr. Cartter's thesis, it would have to be his implicit assumption, which is also reflected in Clark Kerr's introduction, that a Ph.D. is necessary and sufficient to qualify a person for academic positions, and that the excellence of an educational institution is measured by the percentage of doctorates in the faculty. It is a shame that Dr. Cartter, who was prepared to challenge the conventional wisdom in so many other respects, never undertook to examine the basis for his own faith in the superiority of the Ph.D. degree. He never seems to have doubted that employers, if given the choice, would hire Ph.D. holders in preference to persons with other degrees, and he hoped that the surplus of graduates which he clearly saw coming out of the educational pipeline between 1980 and 1985 might lead to an enrichment of the educational process for students and older Americans alike. "By 1990 average student-faculty ratios could be reduced by at least one-third; postsecondary educational opportunities could be extended to all adults who have missed this experience; lifelong recurrent education could become a reality. Whether or not we shall take this bold step toward a 'learning society' depends upon how society orders its priorities, not upon whether there is manpower available to undertake the task."

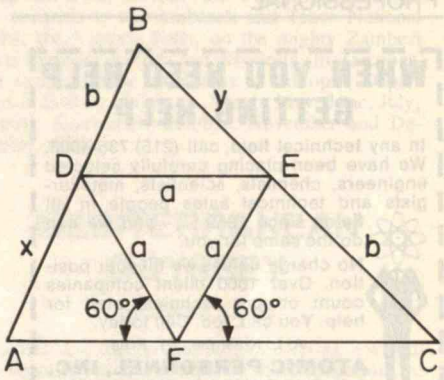
A less optimistic observer might note that the traditional market response to a surplus of manpower is increased competition for any available openings and intensified pressure on the wage and salary structure. If the observer were from industry he might express doubts about the substitutability of doctorate holders for workers with other educational backgrounds, using terms such as "overqualification" and "underutilization" rather than "enrichment" of the work force. In any case, Dr. Cartter has raised serious issues that deserve more attention than they will probably receive. It is up to us, the recipients of his legacy, to decide.

John D. Alden is Executive Secretary of the Engineering Manpower Commission of Engineers Joint Council, a federation of 36 U.S. engineering societies. He is responsible for the Commission's surveys of the enrollments, degrees, and salaries of engineers.

Puzzle

Continued from p. 69

very well have been omitted without altering the conclusion that triangle ABC is equilateral. For example, assuming that DE and AC are parallel, let us start with the diagram shown here:



(I) Assume $x > b$. Since DE and AC are parallel, $x > b \Rightarrow b > y \Rightarrow x > b > y$.
In triangle ADF, $x > b \Rightarrow \angle DFA > \angle ADF \Rightarrow \angle DAF > 60°$ (*) $\Rightarrow a > x$.
Then $a > x > b > y$.
In triangle DBE, $a > y \Rightarrow \angle DBE > \angle BDE = \angle DAF > 60°$, or $\angle DBE > 60°$ (**).
In triangle FEC, $a > b \Rightarrow \angle ECF > \angle EFC = 60°$, or $\angle ECF > 60°$ (***).
Hence, by the strict inequalities (*), (**), (***), the sum of the interior angles of triangle ABC $> 180°$, an impossibility.
(II) Assume $b > x$. Since DE and AC are parallel, $b > x \Rightarrow y > b \Rightarrow y > b > x$. In triangle DFA, $b > x \Rightarrow \angle ADF > 60° \Rightarrow \angle DAF < 60°$ (*) $\Rightarrow x > a \Rightarrow y > b > x > a$.
In triangle FCE, $b > a \Rightarrow \angle ECF < 60°$ (**).
In triangle DEB, $y > a \Rightarrow \angle DBE < \angle BDE = \angle DAF < 60° \Rightarrow \angle DBE < 60°$ (***).
Consequently, by the strict inequalities (*), (**), (***), the sum of the interior angles of triangle ABC is less than 180°, an impossibility in Euclidean plane geometry.
(III) By (I) and (II), since $b > x$ and $x > b$ are impossible, it follows that $b = x$, which implies $y = b$ and $AB = BC$. Furthermore, in triangle DAF, $b = x \Rightarrow b = x = a$. Similarly, triangles FEC, DEB and ABC are found to equilateral.
MAY 5 M. Kaufman has also submitted a detailed analysis.
J/A 5 J. R. Sutton has also responded. And Eric Jamin has responded to all the J/A

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problems and kindly agreed with Martin Gardner's evaluation of "Puzzle Corner."

1975 JUN 1 Several correspondents point out that, given the position resulting from a real game, there is a forced mate in the second play, since Black cannot castle ringside. Black's pawns have made three captures, and — given the position — these captures had to be pieces. Since White is missing only two pieces, his missing pawn had to reach the eighth rank. If this was via the rook file, Black's rook had to have moved at some time. If this was via Bishop 7, the King had to be moved to get out of check. In either case, Black can no longer castle kingside. Therefore White's move is Q x P (K3).

This is summarized:

If Black:	*Then White mates via:*
Castle queenside	P – N 7
K – Q 1	Q x N (Q7)
K – B 1	Q x N (B7)
Anything else	Q x P

1976 JUN 2 Doug Hoylman offers the following:

When I first read the problem I concluded that something must have been left out; how can one draw conclusions from what people said, without any information as to whether the statements are true or false? Now I've read the published solution, and I'm even more confused. I think the key to my bewilderment is the following sentence in Michael Bissell's explanation: "The combinations of a false part 'A' and a true or false part 'B' can be eliminated since they result in a nonsensical statement." Granted, the combination is nonsensical; but *what basis do we have for concluding that Sally is not speaking nonsense?* As the problem stands, I don't see how any conclusion can be reached. Incidentally, I also disagree with the assertion that Breck, Kevin, and Deb cannot all be telling the truth. Nowhere is it stated that the table is rectangular; if it were circular, an arrangement with Breck at noon, Deb at two o'clock, Kevin at four o'clock, and Sally at six o'clock would meet all the conditions.

Proposers' Solutions to Speed Problems

SD 1 The verb "can," as in "I can," means "I am able to."

SD 2 The integers 0, 1, and 2 must be placed on both cubes. The integers 3, 4, 5, 6, 7, and 8 are then placed in any order on the remaining faces (three on each cube). The integer 9 is obtained by turning the 6 upside down!

Allan J. Gottlieb, who is Coordinator of Computer Activities and Assistant Professor of Mathematics at York College of the City University of New York, studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at York College, 150-14 Jamaica Avenue, Jamaica, N.Y., 11451.

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* * *

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Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1978 are also available.

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